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The Engineer

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PUBLIC NOTICES

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—

1. ANCHORS and CABLES for LIGHT VESSEL.
2. SHORT-LINK CHAIN.
3. LOCOMOTIVE ENGINES and TENDERS.
4. STEEL SPRING for LAMINATED and SPIRAL SPRINGS.

Tenders due on the 29th June, 1926, for No. 1, on the 2nd July, 1926, for No. 2, on the 6th July, 1926, for No. 3, and on the 13th July, 1926, for No. 4.
Tender forms obtainable from the above. 2622

Ministry of Transport.
ROADS DEPARTMENT,
EASTERN DIVISION.
WANSFORD BY-PASS, GREAT NORTH ROAD.
HUNTINGDON AND SOKE OF PETERBOROUGH.

The Minister is prepared to receive TENDERS for the CONSTRUCTION of the WANSFORD BY-PASS and BRIDGE, in the counties of Huntingdon and the Soke of Peterborough.

Form of Tender, conditions of Tender, conditions of contract, bill of quantities and specification may be obtained from the Divisional Road Engineer, Roads Department, Eastern Division, Ministry of Transport, 6, Whitehall-gardens, S.W. 1, upon payment of a deposit of £10.

This amount will be returned to the tenderer if his Tender is a bona fide one, and has not been withdrawn prior to the definite acceptance of a Tender by the Minister.

The drawings may be inspected at the Ministry, and copies of the specification, bill of quantities, &c., will be available on and after the 7th June, 1926.

Tenders on the official form, accompanied by a fully priced bill of quantities, and enclosed in a sealed envelope, endorsed "Tender for Wansford By-pass," must reach the undersigned by 10 a.m. on Wednesday, the 23rd June, 1926.

The Minister does not bind himself to accept the lowest or any Tender.

Dated this 2nd day of June, 1926.
(Signed) H. H. PIGGOTT.
Assistant Secretary.
Ministry of Transport. 2550

Assistant Engineer REQUIRED by the GOVERNMENT of KENYA for a tour of 20 to 30 months' service. Salary £450 a year, free quarters and passages and liberal leave on full salary. Candidates, 30 to 40 years of age, must be fully qualified Civil Engineers, who have had good experience in Municipal and Waterworks Engineering.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14624. 2595

Assistant Engineers (7) REQUIRED by the GOVERNMENT of NIGERIA for the PUBLIC WORKS DEPARTMENT for two tours of not less than 12 nor more than 18 months' service in the first instance. Subject to satisfactory service, the officers appointed will be eligible at the expiration of three years' service for confirmation in the permanent and pensionable establishment. Salary £480, rising to £920 a year. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, preferably between 25 and 30 years of age, unmarried, must have passed the examination for A.M.I.C.E., or possess a Degree in Engineering recognised by the Institution as exempting from parts A and B of the examination. They must have had proper technical training and preferably have had not less than two years' subsequent experience on large Engineering or Municipal Works. Candidates possessing other engineering qualifications may apply.—Applications should be made at once by letter, stating age, qualifications and experience, also whether married or single, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14,485. 2460

Civil Engineer Required for the RAILWAY DEPARTMENT of the GOVERNMENT of MAURITIUS on three years' agreement in the first instance. Salary £1000 per year and free passages. Candidates, not over 40 years of age, must be fully trained and qualified, preference being given to those who are corporate members of the Institution of Civil Engineers and have held positions of responsibility on railways, preferably in the tropics, with experience of construction and maintenance. Knowledge of signalling and interlocking will be of advantage.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14042. 2618

Civil Engineer Required by the GOVERNMENT of TANGANYIKA TERRITORY for the Public Works Department (Harbour Works) for a tour of 20 to 30 months' service, with possible extension. Salary £500, rising to £600 a year by annual increments of £25, plus a temporary allowance, at present authorised up to the 30th of June, when its continuance or otherwise will be subject to review, amounting on a salary of £500 a year to £80 a year. Free quarters and passage and liberal leave on full salary. Outfit allowance of £30 on first appointment. Candidates, aged 28 to 45, must have passed the examination for Associate Membership of the Institution of Civil Engineers and have had practical experience of Harbour Works and Marine Surveying.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14462. 2619

Quantity Surveyors (2) REQUIRED by the GOVERNMENT of CEYLON for the Architectural Branch of the Public Works Department for three years' service and possible permanency. Salary £500 a year, rising by annual increments (if made permanent) to £960 a year. (Salary commences at £600 a year if selected candidates has attained the age of 31.) Salary is paid in Ceylon at Rs. 15 to the pound sterling. Free passages; Government quarters available at a low rental. Candidates, 26 to 35 years of age, preferably unmarried, must be fully trained and qualified Quantity Surveyors and have had a good sound and practical knowledge of details, construction and the general work of an Architect and Quantity Surveyor's Office.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14630. 2566

Civil Engineer Required by the GOVERNMENT of TANGANYIKA for a tour of 20 to 30 months' service, with possible extension. Salary £600 a year plus a temporary allowance at present authorised up to the 30th June, when it will be subject to review, amounting on the £600 to £100 a year, plus £100 a year field allowance. Free quarters and passages and liberal leave on full salary. Candidates, aged 30 to 40, must be fully qualified Railway Civil Engineers, who have received good training and experience on recognised European, American or Colonial Railways.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14627. 2597

Civil Engineering Assistant REQUIRED, experienced in the calculation and design of Constructional Steel Work and Reinforced Concrete.

Preference given to ex-Service man.

State age, qualifications, detailed particulars of personal experience, and salary required, Box 982, c/o Pool's Advtg. Service, Ltd., 180, Fleet-street, E.C. 4. 2493

University of Manchester.
(FACULTY OF TECHNOLOGY).
MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.
APPOINTMENT OF PROFESSOR OF MECHANICAL ENGINEERING.

The City Council and the University of Manchester jointly invite APPLICATIONS for the PROFESSORSHIP of MECHANICAL ENGINEERING in the University of Manchester and in the College of Technology.

Commencing salary £1000 a year.

Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester. The last day for the receipt of applications is Thursday, 8th July, 1926.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

B. MOUAT JONES,
Dean of the Faculty.
Principal of the College.
June, 1926. 2567

City of Chichester.
Worthington-Simpson TRIPLE-EXPANSION DUPLEX PUMPING PLANT and LANCASHIRE BOILER FOR SALE. Capacity 40,000 gallons an hour against 250ft. head.

Offers to CITY SURVEYOR and WATER ENGINEER, 61 North-street, Chichester.
7/6/26. 2573

PUBLIC NOTICES

Belfast Harbour.

The Belfast Harbour Commissioners invite TENDERS for the SUPPLY and ERECTION complete of TWO ELECTRICALLY DRIVEN MAIN PUMPS, ONE DRAINAGE PUMP, and ONE PUMP for EMPTYING the CAISSON, at the Hamilton Graving Dock, Belfast, in accordance with the outline specification, &c., which may be obtained from the Harbour Engineer, Mr. T. S. Gilbert, M. Inst. C.E.

Drawings showing the site of the proposed installation have been prepared and may be inspected at the office of the Harbour Engineer.

Tenders must be made on the form provided for the purpose, and must be enclosed in a sealed envelope, endorsed "Tender for Electric Pumps," addressed to the General Manager and Secretary, Belfast Harbour Commissioners, and delivered to him not later than Tuesday, the 29th June, 1926.

The Commissioners do not bind themselves to accept the lowest or any Tender.

M. J. WATKINS,
General Manager and Secretary.
Harbour Office, Belfast,
2nd June, 1926. 2571

Bombay, Baroda and Central INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 25th June, TENDERS for the SUPPLY of :—

1. CRANK and STRAIGHT AXLES for LOCOS.
2. SCREW COUPLINGS.
3. TYRES for CARRIAGES and WAGONS.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of £1 each for Nos. 1 and 2, and 10s. each for No. 3 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.
Offices : The White Mansion,
91, Petty France, Westminster, S.W. 1.
7th June, 1926. 2568

TO LIFT ENGINEERS.

Estimates are Invited for a PASSENGER LIFT at the Coventry and Warwickshire Hospital, Stoney Stanton-road, Coventry. Plans and particulars will be forwarded to Lift Engineers by the Architects, at whose offices application must be made on or before Monday, June 14th, 1926.

T. R. J. MEAKIN and SON,
11, Warwick-row, Coventry. 2591

PUBLIC NOTICES

Administrative County of LONDON.
RE-PAVING OF A PORTION OF THE CARRIAGE-WAY OF THE VICTORIA EMBANKMENT.

The London County Council invites TENDERS for the TAKING UP and REMOVAL of the existing WOOD PAVING of a portion of the carriage-way of the Victoria Embankment at its eastern end near Blackfriars Bridge; the MAKING GOOD (where so required) and RENDERING of the existing CONCRETE FOUNDATION; also the RE-PAVING of the same with CREOSOTED WOOD BLOCKS and other works incidental thereto.

The specification, form of Tender, &c., may be obtained on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £3 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 28th June, 1926, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
2575 Clerk of the London County Council.

Administrative County of LONDON.
REPAIRS TO PAVEMENTS OF CARRIAGE-WAYS OF BLACKWALL AND ROTHERHITHE TUNNELS.

The London County Council invites TENDERS for REPAIRS to the GRANITE SETT and WOOD PAVING and the GRANITE CHANNELLING of BLACKWALL and ROTHERHITHE TUNNELS.

The specification, form of Tender, drawings, &c. may be obtained on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £3 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before the payment of the fee.

The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 28th June, 1926, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
2574 Clerk of the London County Council.

Surrey County Council.
HIGHWAYS AND BRIDGES DEPARTMENT.

The Surrey County Council invite TENDERS for the WORKS to be carried out in the CONSTRUCTION of the following FERRO-CONCRETE BRIDGES over the Southern Railway, together with certain Accessory Works in connection therewith :—

Bridge No. 1 is over the Guildford Branch Railway, in the Parish of Thames Ditton.

Bridge No. 2 is over the Main Line, in the Parish of Merton.

Bridge No. 3 is over West Barnes-lane and the Epsom Branch Line, in the Parish of Merton.

Copies of the form of Tender, instruction to persons desirous of tendering, and bill of quantities may be obtained from the undersigned, and the form of contract, general conditions, specification and drawings may be examined at the office of the County Surveyor on weekdays (except Saturdays) from 10 a.m. to 4.30 p.m. on and after Tuesday, the 15th instant, on payment of a deposit of Ten Guineas, which will be refunded upon receipt of the above-mentioned documents complete with a bona fide Tender, and each Tender must be submitted, enclosed in a sealed envelope, endorsed "Tender for Bridge at ——," and lodged not later than 9 a.m., 28th June, 1926.

The Council does not bind itself to accept the lowest or any Tender.

W. P. ROBINSON, Assoc. M. Inst. C.E.,
County Surveyor.
County Hall Annexe,
Kingston-on-Thames,
9th June, 1926. 2626

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PUBLIC NOTICES

City of Bradford.

SEWAGE DEPARTMENT.
SURPLUS PLANT FOR DISPOSAL.

ONE "Ruston" No. 15 STEAM CRANE NAVVY, 2 c.y. bucket, 4ft. 8½in. gauge.

50 (about) "Hudson's" 20 c.ft., 2ft. gauge, "U" shape TIPPING WAGONS.

3 OPEN-TOP PRESSED STEEL TANKS, 140ft. by 46ft. by 12ft. high.

One 50 B.H.P. SEMI-DIESEL OIL ENGINE, by Robson.

One 10/20 H.P. "Titan" TRACTOR, by the International Harvester Corporation, Chicago.

The above plant has been little used and is in excellent condition, and may be inspected at the Esholt Sewage Disposal Works (station, Apperley Bridge and Rawdon, L.M. & S.).

Further particulars may be obtained from, and offers to be submitted to, the SEWAGE WORKS ENGINEER, Esholt Hall, near Shipley.

10th May, 1926. 2367

The South Indian Railway Company, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of:—

1. EXPANDED METAL SCREENS.
2. STRUCTURAL STEEL WORK.
3. 10 STEEL TIMBER TRUCKS and 60 STEEL COVERED GOODS WAGONS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Expanded Metal Screens," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 2nd July, 1926.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of Specification No. 1, and of £1 for each copy of Specifications Nos. 2 and 3.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1,
9th June, 1926. 2820

Napier Harbour Board (New ZEALAND).

RESIDENT ENGINEERSHIP.

APPLICATIONS are INVITED for the above POSITION.

Salary £1250 per annum.

Canvassing members of the Napier Harbour Board will disqualify applicants.

Applications to be addressed to the SECRETARY of the NAPIER HARBOUR BOARD and delivered at the Harbour Board Office, Napier, New Zealand, not later than Monday, October 11th, 1926.

A copy of the conditions can be obtained from the Board's London Agents, Messrs. W. and A. McArthur, Ltd., 18/19, Silk-street, Cripplegate, London, E.C. 2. 2416

The Commissioners for the PORT OF CALCUTTA.

The Commissioners invite APPLICATIONS for the APPOINTMENT of an ASSISTANT EXECUTIVE ENGINEER. Candidates should have had experience in Dock Construction, and preference will be given to man able to make diving inspections and who is corporate member of the Institution of Civil Engineers.

Salary offered is Rupees 700 per month, rising by Rupees 50 per month each year to Rupees 1050 per month. Period of engagement about 2½ years. Candidates should not be more than 35 years of age.

Applications, together with copies of testimonials, should be addressed to the undersigned.

Mr. J. ANGUS.

Clutha House, 10, Princes-street,
London, S.W. 1. 2570

The Directors of the Windsor Electrical Installation Company, Ltd., and the Slough and Datchet Electric Supply Company, Ltd.,

are prepared to receive APPLICATIONS for the POSITION of DEPUTY ENGINEER in connection with the two undertakings. Applicants, who should preferably be public school men, should have received a thorough theoretical and practical training, and should have held positions of responsibility in electrical supply undertakings. The successful candidate will be required to assist generally in the engineering and commercial management of the two companies, acting under the directions of the Chief Engineer and Manager. The salary offered will commence at £600 per annum.

Applications, stating age and full particulars of the candidates' training and experience, and accompanied by copies of not more than four testimonials, should be addressed to E. MACGREGOR DUNCAN, Esq., 21, Old Queen-street, Westminster, London, S.W. 1, and should be received not later than Monday, June 28th, 1926, the envelope being marked "Appointment." 2608

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS UNLESS SPECIFICALLY REQUESTED.

WANTED by a Large Firm of Structural Engineers (European) in India, a fully qualified ENGINEER. Good commercial knowledge and experience in negotiating contracts essential, also drawing-office and field experience. Public school man, aged 30-38, preferred.—Address, giving full particulars of training, experience, age, &c., 2612, The Engineer Office. 2612 A

WANTED, COMMERCIAL ENGINEER, with Experience of Water Supply Systems and Electrically Driven Pumps to organise sale of American speciality in this country on salary and commission.—Address, stating experience, with copies of recent references, 2586, The Engineer Office. 2586 A

WANTED for Australia, Experienced WORKS MANAGER for combined Starch, Glucose, Dextrine Plant from Potatoes.—Full particulars, salary required, when free, to JAMES LIVINGSTON, Ltd., Imperial House, Kingsway, London. 2587 A

WANTED, MANAGER for Structural Engineers' Works and Stock Yard; good salary offered to suitable man.—Address, 2576, The Engineer Office. 2576 A

WANTED, PRODUCTION and MAINTENANCE ENGINEER for progressive appointment. A good knowledge of Modern Light Foundry, Press and Machine Shop practice essential.—Box 743, Mundy, Gilbert and Troman's Advertising Offices, Birmingham. P1993 A

ASSISTANT REQD., Patent Dept. Engineering Firm in Midlands; good knowledge Electrical, Mechanical and Radio Eng. essential.—Write, stating age, expce., salary, Box 654, Sells, Fleet-street, E.C. 4. 2580 A

ASSISTANT CIVIL ENGINEER, Experienced in Waterworks, Sewer and Sewage Disposal Construction, for Ecuador. One to three years. Not over 35, must be single. Preferably speak Spanish. State full details experience, salary required, references.—Box 54, c/o Judd's, 47, Gresham-street, E.C. 2. 2610 A

ASSISTANT REQUIRED in Water Engineer's Office for Waterworks on South Coast of England; must be good Surveyor, Leveller and Draughtsman, possessing technical knowledge, and have had experience in Pumping Station and Distribution Departments, knowledge of Building Construction desirable; age about 25.—Write, with full particulars, salary required, and when disengaged, to Z. E. W. C., c.o. Deacon's, Leadenhall-street. 2565 A

CHIEF ENGINEER WANTED for Group of Collieries in Durham with an output of 4000 tons per day, thoroughly experienced in all branches of modern Mechanical and Electrical Engineering and capable of laying out plant for the modernisation of collieries. Applicants must be energetic and preferably have held a similar position.—Address, giving particulars of experience, copies of recent testimonials, and wage required, 2603, The Engineer Office. 2603 A

CONSTRUCTIONAL STEEL WORK.—WANTED for works in Midlands, first-class MAN to Plan Progress and Urge Production through all stages. Must be energetic and persistent and able to increase output. State age, salary, and when at liberty.—Address, 2558, The Engineer Office. 2558 A

CONSULTING ENGINEER and MANUFACTURER has an OPENING in his London Office for a PREMIUM PUPIL. Must have a good general education, some knowledge of drawing an advantage. Would be given a thorough training with a view to a permanent post when proficient. Interview by appointment.—Address, 1988, The Engineer Office. 2019 A

ENGINEER WANTED for Service in London. One able to Inspect and Test all Classes of Machinery preparatory to export. Must be capable draughtsman and correspondent and have practical knowledge of Tin Dredge Construction and Dredging Machinery.—Write fully, stating age, where educated, and give full particulars of training and positions held, salary required, &c., to W. A., 64, Cannon-street, London, E.C. 4. 2593 A

ESTIMATOR REQD., Thoroughly Expd. in Mass production methods on small engineering and instrument work. Man with planning exp. preferred.—Address, stating full particulars, salary reqd., 2542, The Engineer Office. 2542 A

REQUIRED for Birmingham, REPRESENTATIVE (not over 30), on salary and commission, for Sale of Steel Office and Factory Shelving, Lockers, Cupboards, &c. Must be able to make own plans, take measurements and discuss lay-outs with prospective customers.—Address with fullest particulars P2000, The Engineer Office. P2000 A

STRUCTURAL ENGINEER WANTED for a Bridge and Roof Works in India. Must have had office and drawing-office experience; unmarried; 5 years' agreement. Commencing salary the equivalent of £850 per annum.—Reply, with full particulars, to Box "Z.G. 125," c/o Deacon's Advertising Offices, Fenchurch-avenue, London, E.C. 3. 2631 A

STRUCTURAL STEEL WORK DRAUGHTSMAN, with sound experience of Crane Girders and Crane Structures. State age, wage, and experience.—Address, 2632, The Engineer Office. 2632 A

TECHNICAL ASSISTANT to MANAGING DIRECTOR REQUIRED by Motor Car Manufacturers; must have had first-class technical education and possess sound workshop experience and a good knowledge of Purchasing Steels and Raw Materials; experience in the Control of Outside Contracts and Stores Records an advantage.—Address, stating age, experience and salary expected, 2561, The Engineer Office. 2561 A

TOOL and PLANT ENGINEER WANTED, First-class man, to control design and manufacture of Press Tools, Drill Jigs, &c., and to be responsible for the efficiency and upkeep of plant and tools. Must be good organiser and have held similar post. State age and salary required and give full particulars of experience.—Address, 2615, The Engineer Office. 2615 A

WORKS MANAGER for Medium-sized Engineering Works. Thoroughly experienced in use of Heavy and Light Machine Tools and having sound technical education. Good disciplinarian. Experience in Sugar Machinery an advantage. Age 35 to 40.—Address, with full particulars, stating salary required, with copies of testimonials, P1990, The Engineer Office. P1990 A

CHIEF DRAUGHTSMAN REQUIRED for Well-known Lancashire Engineering Co., with experience in Steam Engines and Condensing Plants, also large Compressors.

Application only will be considered from gentlemen having held similar position and with necessary qualifications.

State age and salary expected, with full details.
Address, 2609, The Engineer Office. 2609 A

DESIGNER WANTED, First-class Man, Capable of designing and developing improvements in small machines. Must have originality and initiative and be thoroughly practical and conversant with manufacturing requirements. State age and salary required and give full particulars of experience.—Address, 2614, The Engineer Office. 2614 A

DEVELOPMENT DRAUGHTSMAN. — APPLICATIONS are INVITED from DRAUGHTSMEN having knowledge of Railway and Ships' Specialities, such as Carriage Fittings and Train and Ships' Heating. Applicants should state full particulars of experience, salary required, &c.—Address, 2625, The Engineer Office. 2625 A

DRAUGHTSMAN IMPROVER WANTED in General Engineer's Office, East Coast. Must have shop knowledge. State experience, age, &c.—Address, P1902, The Engineer Office. P1902 A

DRAUGHTSMEN (MECHANICAL), London Area, WANTED, for first-class Design Work. Only thoroughly capable men need apply.—Address, 2523 The Engineer Office. 2523 A

DRAUGHTSMAN REQUIRED, Age 25-7, Single; accustomed to Elevating and Conveying Machinery, also Constructional Steel Work. State age, experience, and salary required.—Address, 2616, The Engineer Office. 2616 A

DRAUGHTSMAN REQUIRED, with Good General knowledge of Small Marine Engine Work. Preference will be given to one fully conversant with modern Marine Auxiliaries.—Apply, stating age, particulars of past experience, salary expected, &c., to A. G. MUMFORD, Ltd., Engineers, Colchester. 2618 A

EXPERIENCED STRUCTURAL DRAUGHTSMAN REQUIRED for position as Chief Designer.—Apply, stating full particulars, to HEENAN and FROUDE, Ltd., Structural Engineers, Newton Heath, Manchester. 2624 A

FIRST-CLASS DRAUGHTSMAN REQUIRED, accustomed to Detailing Medium and Heavy Structural and Mechanical Work. State age, experience, and salary required.—GILLETT and JOHNSTON, THE CROYDON BELL FOUNDRY, Ltd., Croydon. 2560 A

HEAD DRAUGHTSMAN REQUIRED for India, for General Engineering Works; must have had good theoretical and practical training in Structural Work; must be capable of taking charge of drawing-office and designing bridges, tanks, roofs, and all classes of steel structures; aged about 30, single preferred.—Application, stating age and giving full particulars of training and experience, with copies of recent testimonials, to be sent to Z. O. 900, c/o Deacon's Advertising Offices, Fenchurch-avenue, London, E.C. 3. 2594 A

GOOD DETAILING DRAUGHTSMAN REQUIRED for London office; used to London steel-framed buildings. State age, experience and salary required.—Address, P1989, The Engineer Office. P1989 A

SHIP DRAUGHTSMAN (Experienced) WANTED by Shipbuilders and Ship Repairers in China. Must have been trained in a small shipyard with experience in designing Light-draught Vessels. Aged 30 to 40. Salary £40 per month for 3 years' engagement.—Address, fully detailing experience and technical training, P1987, The Engineer Office. P1987 A

SKILFUL TRACER and LETTERER WANTED on Civil Engineering Work in City office for two months. State salary required, experience.—Box 55, c/o Judd's, 47, Gresham-street, E.C. 2. 2611 A

STRUCTURAL DRAUGHTSMAN WANTED in London IMMEDIATELY. Experience in Bridge-work desirable. State age, experience, and salary required.—Address, P2004, The Engineer Office. P2004 A

FOREMAN MACHINIST. Used to Capstans, Broaching, Milling Machines, &c.; must be good organiser and strict disciplinarian.—Address, stating experience, salary required, &c., 2569, The Engineer Office. 2569 A

FOREMAN REQUIRED by Large Concern; Must have extensive knowledge of the most up-to-date methods applying to manufacture of modern type Graphite Crucibles, &c.—Address, stating experience fully, 2578, The Engineer Office. 2578 A

PETER BROTHERHOOD, Ltd., Peterborough, wish to engage a FOREMAN of IRONFOUNDRY.—Apply by letter, giving full particulars of experience and state wage required. 2584 A

MECHANICS, FITTERS and ENGINEERS, Desiring more congenial and lucrative employment, should write for particulars of my intensive course in draughtsmanship. There is an increasing demand for qualified draughtsmen and you can learn this interesting profession while you are earning. Postal or private tuition by arrangement.—PERCY PITMAN, M.I. Mech. E., 25, Victoria-street, Westminster, S.W.1. 2007 A

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For continuation of Small Advertisements see page 3.

A Seven-Day Journal

Internal Combustion Locomotives.

PARTICULARS have now been published of the prizes which are being offered by the Soviet Government for designs of internal combustion locomotives. Three prizes are to be awarded. The value of the first is to be £6000, of the second £4000, and of the third £2500. The prime mover may be an internal combustion engine alone or in combination with a steam engine, and the nature of the transmission gear is left entirely in the discretion of the designers. The locomotive as a whole must be suitable for the Russian railway gauge, which is 1·524 m., or five feet, and must pass the Russian gauge for rolling stock on curves of a radius of 250 m. The tractive effort for goods engines must be not less than 15,000 kilos. at 16 kiloms. per hour, and not less than 12,000 kilos. at 30 kiloms. per hour for passenger engines. The maximum speeds for the two types must not fall below 50 kiloms. per hour and 90 kiloms. per hour respectively. The axle load may be 20 tons for all axles except the leading axle, on which it must not exceed 13 tons. In making the awards the following points will be considered, amongst others:—Cost of construction and maintenance; fuel consumption; reliability; simplicity of operation and weight. The last day for the receipt of competitive designs is November 21st, 1926. Full particulars can be obtained from the Technical Bureau of the I.C. Locomotive Commission, Moscow, Gorokhovaya ul 8, Appt 57.

Alleged Faults in Petrol Pumps.

THE distinct preference shown by most motorists to have their petrol supplies delivered to them from roadside petrol pumps rather than from cans will perhaps receive a check from the allegations of inaccuracy levelled against these appliances by Mr. F. P. Bolshaw at the annual general meeting last week of the Incorporated Society of Inspectors of Weights and Measures. Mr. Bolshaw, Chief Inspector of Weights and Measures at Liverpool, has been studying the behaviour of petrol pumps of the piston type. Out of 124 pumps tested, 65 per cent. gave short measure on the first pull, 12 per cent. gave over measure, and 23 per cent. were correct. Legally, he said, petrol pumps of the piston type were measuring instruments and not measures, and therefore did not require to be stamped under the Weights and Measures Act. Many of them, nevertheless, were stamped, but the stamping only guaranteed that the pumps gave correct measure on the day of examination and did not ensure that the accuracy would be maintained even on the next day. The low specific gravity of petrol made it difficult to prevent its leaking back into the supply chamber. A particle of grit on the valve seating, a defective piston leather, or a too speedy operation of the rotary handle would cause short measure to be given. It was most essential, Mr. Bolshaw proceeded, that the piston leather should be pliable; but, unfortunately, petrol had the effect of making the leather so hard that it would not adhere to the sides. It was, he held, practically an impossibility to make a piston type petrol pump that could be guaranteed always to deliver the correct quantity of petrol. In some cases the supplies of the pumps employed a special service staff for attending to complaints and for testing the pumps periodically, and had undertaken to keep the pumps in order for all time free of charge. Yet with all these precautions 77 per cent of the pumps he had tested were found to be incorrect. It is only fair to state that Mr. Bolshaw mentioned certain other types of pump on the market which in his judgment could be relied upon to give accurate measure. Some makers of piston type pumps have declared that there is no justification for Mr. Bolshaw's condemnation of these appliances. Complete refutation, however, would seem to demand that the makers should employ an independent party to test the accuracy of as many pumps, selected at random, as Mr. Bolshaw examined.

Magnetic Observations at Greenwich.

IN the report of the Astronomer Royal to the Board of Visitors which was read at the annual visitation of the Royal Observatory at Greenwich, on Saturday, June 5th, reference was made to the discontinuance of magnetic observations, owing to the magnetic disturbances caused by electric trains. It has been usual to observe photographically the variations in declination, north force, and vertical force at Greenwich, and to make absolute measurements of declination, horizontal force, and dip at various times during each week. On February 28th a regular train service was begun on the electrified section of the Southern Railway, which passes through New Cross and Lewisham, about a mile from the Observatory. The vertical force traces were so strongly disturbed from that date, that further observations were deemed valueless, and readings were discontinued. The traces of the declination and north force were also subject to simultaneous disturbances after May 10th, when further sections of the railway were brought into use. After July, when the full service of electric trains will be established further magnetic observations at Greenwich will cease. The new magnetic observing station at Abinger, near Dorking, in Surrey, has now been in operation since early in 1925. Progress has been made in the comparison of results obtained at Greenwich and Abinger respectively. On thirty selected days of disturbance the declination movements at Abinger were shown on the average to be 2 per cent. smaller in extent than those at Greenwich. In this connection a comparison of the traces obtained at Stonyhurst College Observatory on the same days was also made; it showed a magnification of about 20 per cent. Similar comparisons of the traces of horizontal force are being made.

French Cruiser Trials.

AFTER long delays, caused by certain modifications in the original design, the French cruiser Duguay-Trouin is now running her trials off Brest. Laid down in August, 1922, she was to have been ready for service in thirty months, but she has actually taken nearly four years to complete. She, with her two sisters, Lamotte-Picquet and Primauguet, has been built expressly for high speed, and fighting power has in some degree been sacrificed in order to achieve this aim. The displacement is 7880 tons, increasing to 9350 tons at full load. The lines are very fine, the overall length of 604ft. being 34ft. greater than that of H.M.S. Enterprise, and the breadth is 56½ft., as compared with 54½ft. in the British vessel. The Duguay-Trouin is engined with four sets of Parsons geared turbines, taking steam from eight Guyot boilers. The contract calls for 100,000 shaft horse-power, equivalent to a speed of 34 knots. In the initial trials, which took place last month, the ship developed 90,000 shaft horse-power and 33·5 knots, the weather conditions being rather unfavourable. The machinery stood up well to the strain, and the ship's engineers are confident that the designed power and speed will be substantially exceeded when the next trials are held. This is the first really swift cruiser which the French Navy has possessed for many years. Her armament of eight 6·1in. 55 cal. guns, paired in turrets, has been criticised as unduly light, though it is considerably more powerful than that of our "E" class ships. The weak point about the French ship is the virtual absence of protection. She has no vertical armour, the deck plating over vital parts is very flimsy, and the turrets are barely splinter-proof.

Sir W. G. Armstrong, Whitworth & Co., Ltd

THE report which was presented by Lord Southborough at the annual meeting of Sir W. G. Armstrong, Whitworth and Co., Ltd., in Newcastle, on Tuesday, June 8th, is the history of a famous armament firm endeavouring to meet the conditions imposed by the restriction of armaments. This is not the place to discuss the moral and economic effects of the Washington policy, but it may be said that had the restriction not been adopted, the troubles in which Armstrongs—and many other great firms—are now involved would never have arisen. According to Lord Southborough, about 90 per cent. of the work done by Armstrongs was armament work. To drop the bulk of that work and to take up something else that would replace it was no easy matter, and it was made much more difficult by the period of depression from which we had not emerged when the coal strike involved us as deeply as ever. We need say nothing of the various ramifications which the change over from war to peace products were held to necessitate; in some, Armstrongs have found themselves put in very serious financial position, in others, the investments are good and profits are being earned. The principal cause of the bad position in which the famous firm is struggling was the attempt to establish a great contracting business and particular its participation in the Newfoundland Power and Paper Company. About that enterprise Lord Southborough had a good deal to say, and it is satisfactory to know that three of the mills are at work turning out 300 tons of newsprint per day, and that the fourth mill of the same capacity is likely to be completed at an early date. We gave some particulars of the financial position and reconstruction of the Board in this journal on June 4th, and need only add now, that Mr. A. H. J. Cochrane and Sir George Hadcock have been re-elected, and that Mr. Frater Taylor, who has been engaged for some time on the readjustment of the affairs of the company, has been appointed a director.

The Eguzon Barrage.

LAST week there was put into service the first of the great barrages which are to provide a source of electrical energy in the Massif Central of France for the electrification of the Paris-Orleans railway system and for distribution to Gennevilliers, where it will be employed as a supplementary supply for the Paris district when the existing plant is working under full load. The barrage of Eguzon, in the department of Indre, has a height of 200ft. and a length of 836ft., and it creates a lake 11 miles long and varying in width up to a thousand yards. The quantity of concrete used in the construction was 210,000 cubic metres. At each end of the barrage there is a huge concrete tower, where a steel pipe, 13ft. 9in. in diameter, takes the water for the turbines at 65ft. below he normal level. The generating station contains five turbo-alternators of 10,000 kilowatts. The energy produced is about 120 million kilowatt-hours. It will be employed mainly for the operation of the Paris-Vierzon line, which is already in use between Paris and Etampes and will be extended to Vierzon in January next. The remainder will be distributed locally, and more especially to Paris, with two cables, one of 90,000 and the other of 100,000 volts. The former is already installed and is supplying current from Eguzon to the Gennevilliers station. It is stated that the installation, when completed, will economise about a quarter of a million tons of coal a year. Two other large barrages and generating stations are now under construction in the Auvergne, one at Coindre and the other at Cellette.

Dating and Sealing Patents.

THE announcement is made that the Board of Trade has appointed a Committee consisting of Mr. J. Whitehead, K.C. (chairman), Mr. H. A. Gill, M.A., Mr. A. J. Martin, O.B.E., Major-General Sir Philip Nash, K.C.M.G., C.B., and Mr. J. Swinburne, M. Inst. C.E., F.R.S., to inquire into and report whether any and, if so, what change is desirable in the practice of the United Kingdom of (*a*) dating and sealing patents applied for under Section 91 of the Patents Acts, 1907 and 1919, as of the date of the application in the foreign State; (*b*) dating and sealing other patents as of the date of application, as provided by Section 13 of the Acts. The secretary to the Committee is Mr. B. G. Crewe, the Patent Office, 25, Southampton-buildings, London, W.C. 2, to whom all communications relating to the work of the Committee should be addressed.

The Coal Dispute.

WHEN on Thursday, the 3rd inst., Mr. Evan Williams addressed a letter to Mr. Herbert Smith in which he suggested that three or four of the mine-owners and an equal number of miners' representatives should informally meet to discuss how settlement negotiations might proceed, hope was entertained that some progress in the direction of peace might be made. On Tuesday, the 8th inst., a conference took place between Mr. Evan Williams, Mr. C. P. Crayshaw, Sir Adam Nimmo and Mr. W. A. Lee representing the Mining Association, and Mr. Herbert Smith, Mr. T. Richards, Mr. Richardson and Mr. A. J. Cook representing the Miners' Federation. That conference lasted three and a-half hours, but it proved abortive and the deadlock continues. Before the meeting the miners' representatives had let it be understood that they would not agree to any change in wages or hours. At the meeting they suggested that selling agencies, in which the management and the miners should be represented, should fix the price of coal high enough to maintain the wages of the 1924 agreement. The owners pointed out that the fixing of some unknown high price for coal would adversely effect other industries and would jeopardise export trade. In answer to this the miners' representatives allowed it to be believed that their first consideration was with the mining industry and not other industries, and, further, that if sufficient foreign orders could not be secured, the export trade might be subsidised. In reply to the question as to how many pits could pay present wages on a seven-hour day, it was conceded that probably only 50 per cent. could do so, which would involve the unemployment of about 500,000 men. The atmosphere of the meeting was evidently a very strained one and no progress was possible.

St. Paul's Cathedral.

FROM the report of the Works Sub-Committee, which was presented to the Committee for the Preservation of St. Paul's on Monday, the 8th inst., it would seem that satisfactory progress is being made with the work of preserving St. Paul's Cathedral. The report covers the period since the previous report was presented on October 21st last year. During the period from January 1st, 1925, until March 31st, 1926, a total of over £25,500 has been expended. It is satisfactory to note that there is still no indication that any settlement is taking place in the area of the dome. The work of renovation has included the cementation of the crypt portions of the south transept piers and two nave piers, and the drilling of the crypt portion of the choir piers has also been completed. The air compressor installation has been increased, and considerable experimental work has also been carried out at the National Physical Laboratory, with a view to evolving a satisfactory pattern of stainless steel reinforcement rod which, while retaining its full strength, will be of such a section and shape that a satisfactory grip on the cement grout is obtained. Further exploration has resulted in the determining of the exact positions of the original iron ties between the piers and bastions. By means of an electrical method the majority of these ties have been shown to be broken and their renewal is being considered. Meanwhile temporary steel struts have been put in from pier to pier under the four main coffered arches as a precautionary measure. The most satisfactory position of ties is being studied by means of models. Progress has also been made in the instrumental survey of piers and arches, and a careful record of the exact position of the Cathedral fabric at the present time is being prepared.

"Spread" of Metal in Rolling.

By C. E. DAVIES, A.M.I. Mech. E., M. Inst. Met.

No. I.

THE fact that metal, in the process of reduction in thickness between rolls, is widened, besides being elongated, is well known; but so far no satisfactory method of determining the amount of this increase in the dimension parallel to the axis of the rolls has been devised. In hot rolling work, this "spread," as it is usually termed, is a most important factor for consideration in the design of roll passes for section rolling, and several attempts have been made to devise a formula by means of which the amount of spread, under any specified conditions of rolling can be calculated. But it would appear that no really reliable formula is as yet available, and roll designing is still mainly guided by experience, the final adjustments being made by trial and error.

This position is rather to be expected, owing to the many variable factors which have influence on the relation between longitudinal and transverse extension in the rolling of hot metal, into the various shapes required in the ordinary course of rolling mill production.

The present writer has confined attention to the simpler problem of the same nature in cold rolling work. Simpler, because the variable and important temperature factor is eliminated, and also because cold rolling is mainly confined to the production of simple flat and rectangular sections, but it is hoped that any light which may be thrown on this simpler question of spread in cold rolling work may assist in the solution of the more difficult case of hot rolling.

Generally, in cold rolling strip metal and sheet the amount of spread is proportionately small, and is, moreover, frequently not of any direct importance, although, as will be seen later, the tendency of the rolls to cause transverse extension as well as elongation in the direction of rolling has a very considerable effect on the finished product, introducing, as it does, irregularity in the elongation of the metal at different longitudinal sections. This, especially with hard metals, is the main difficulty in obtaining exact uniformity of thickness across the width of the metal rolled; and the production of perfectly flat strip or sheet free from "buckles."

The simplest and most obvious case where determination of spread is of practical importance occurs in the class of cold rolling work known as wire flattening, this process being the production of flat strips and small rectangular sections from round wire or rod. A great quantity of narrow strip in both steel and non-ferrous metals is produced in this way, and the problem presented is to determine the diameter of round section required before rolling, which will give, when the thickness is reduced to the specified figure, the desired width; that is to say, to produce a strip or rectangular section of width W and thickness T, what is the necessary diameter of the round section before the pass or passes?

Sometimes, no very great accuracy in the width dimension is required, but, even then, it is clearly economy to commence with the minimum diameter of wire or rod which will give the desired proportions.

Frequently the permissible limits for widths are almost as fine as those laid down for the thickness, and in such cases without some method of foretelling the amount of spread which may be expected after the reduction in thickness, accuracy in width of rolled strip is difficult to obtain. Reducing from square or rectangular sections to strip is not so common; as for narrow strip, it is more economical to reduce from the circular section, and wider strip is either, as in the case of steel, reduced from strip already hot rolled to dimensions approaching the finished sizes or, with brass, rolled in considerable width and afterwards slit into narrower bands. Comparatively, thick rectangular sections in non-ferrous metals are frequently finished by drawing through dies, but the modern tendency is to substitute rolling for drawing, in such cases, except for a finishing pass to give square edges. For this determination of spread in rolling is of practical importance. With the view to discovering, if possible, some guiding principle which would facilitate the calculation of the spread resulting from any given reduction in thickness, the writer has collected a quantity of experimental data, the greater part of which were obtained from trials carried out on an experimental rolling plant installed by Messrs. W. H. A. Robertson and Co. in their works at Bedford. This mill, which is fitted with rolls 10in. diameter and has been operated at different speeds, has afforded valuable information for guidance in the design of roll passes for specific cases, but before the possibilities of any general law could be investigated a very great number of experiments, with different metal sections, varying reductions, &c., had to be carried out.

At first sight, the results given by these experiments and also from data obtained from other sources, appeared to be very irregular, and it was concluded that the spread resulting from rolling was dependent on the following factors:—

(1) Nature and condition of metal rolled.
(2) Reduction in thickness per pass.
(3) Diameter of rolls.
(4) Also, possibly, the condition of the roll surfaces.

With so many varying conditions, if each were to

TABLE I.—*Wire Flattening Tests, Round to Flat.*

Test No.	Dia. D.	Thickness, T_2.	Width, W_2.	% red'n.	% spread.	Ratio % spread / % reduction.	Material.	P_1.	P_2.	K P_2/P_1.	Roll dia.	Speed.
	in.	in.	in.								in.	r.p.m.
6	·213	·198	·222	7·05	4·2	·595	B.D.S.	·67	·84	1·25	10	29
3	·250	·202	·266	19·2	6·4	·333	B.D.S.	·785	·936	1·19	10	29
12	·5	·392	·545	21·5	9·0	·420	Bk. M.S.	1·57	1·874	1·195	10	40
13	·5	·308	·550	26·5	11·8	·445	Bk. M.S.	1·57	1·854	1·185	10	40
14	·5	·344	·589	31·0	17·8	·575	Bk. M.S.	1·57	1·866	1·19	10	40
4	·1406	·093	·167	33·6	18·8	·56	Wire	·44	·52	1·185	9	—
5	·1406	·093	·171	33·6	21·5	·64	Wire	·44	·528	1·20	4	—
15	·5	·322	·608	35·5	21·5	·605	Bk. M.S.	1·57	1·860	1·185	10	40
16	·5	·297	·643	40·5	28·5	·705	Bk. M.S.	1·57	1·880	1·20	10	40
0	·072	·041	·0985	43·0	36·8	·855	Copper	·226	·279	1·235	6	50
1	·373	·197	·486	47·0	30·5	·65	B.D.S.	1·17	1·366	1·17	10	29
2	·373	·196	·481	47·5	29·0	·61	Bk. M.S.	1·17	1·354	1·16	10	29
7	·178	·091	·243	49·0	36·5	·745	Wire	·56	·668	1·19	10	29
20	·375	·192	·491	49·0	31·0	·632	Copper	1·18	1·366	1·16	10	29
17	·1875	·095	·287	49·5	53·0	1·07	Bk. M.S.	·59	·764	1·30	10	40
8	·143	·071	·208	50·5	45·5	·90	Wire	·45	·558	1·24	10	29
18	·2187	·094	·375	57·5	71·5	1·24	Bk. M.S.	·685	·938	1·37	10	40
19	·252	·094	·440	62·5	74·5	1·19	Bk. M.S.	·79	1·068	1·35	10	40

D = diameter before rolling. T_2 = thickness after rolling. W_2 = width after rolling. P_1 = perimeter before rolling = π D. P_2 = perimeter after rolling $(T_2 + W_2)$ 2. K = P_1/P_2.

TABLE II.—*Wire Flattening Tests, Round to Flat.*

Successive reductions on M.S. (bright drawn) ·213in. diameter, rolls, 10in. diameter, 29 R.P.M. (P_0 = ·67).

Pass No.	T_1.	T_2.	W_2.	% red'n.	Total % red'n.	% spread.	Total % spread.	Ratio Total % spread / Total % red'n.	P_1.	P_2.	K P_2/P_0.	k P_2/P_1.
	in.	in.	in.									
1	·213 dia.	·198	·222	7·05	7·05	4·2	4·2	·595	·67 (P_0).	·84	1·25	1·25
2	·198	·178	·232	10·1	16·4	4·5	8·95	·546	·84	·820	1·225	·975
3	·178	·161	·243	9·6	24·5	4·75	14·1	·575	·82	·808	1·21	·985
4	·161	·141	·260	12·4	33·7	7·0	22·1	·656	·808	·802	1·20	·995
5	·141	·121	·275	14·2	43·2	5·75	29·0	·672	·802	·792	1·18	·99
6	·121	·106	·293	12·4	50·3	6·5	37·5	·745	·792	·798	1·19	1·01
7	·106	·092	·305	13·2	57·0	4·1	43·4	·762	·798	·794	1·185	·995

T_1 = thickness (or in first pass diameter) before rolling. T_2 = thickness after rolling pass. W_2 = width after rolling pass. P_0 = original perimeter (π D). P_1 = perimeter before pass. P_2 = perimeter after pass. K = P_2/P_0 (ratio of perimeter after pass to original perimeter). k = P_2/P_1 (ratio of perimeter after pass to perimeter before pass).

TABLE III.—*Wire Flattening Tests, Square to Flat.*

Rolls 10in. diameter, 29 R.P.M. T_1 = side of square.

Test No.	T_1.	T_2.	W_2.	% reduction.	% spread.	Ratio % spread / % reduction	Metal.	P_1.	P_2.	K P_2/P_1.
	in.	in.	in.							
23	·252	·209	·270	17·1	7·15	·418	B.D.S.	1·008	·958	·945
24	·505	·387	·575	23·4	13·9	·595	Brass	2·02	1·924	·955
21	·375	·199	·433	47·0	15·5	·328	B.D.S.	1·5	1·264	·845
22	·375	·197	·450	47·5	20·0	·420	Blk. M.S.	1·5	1·294	·865

T_1 = side of square before rolling. T_2 = thickness after rolling. W_2 = width after rolling. P_1 = perimeter before rolling = 4 T_1. P_2 = perimeter after rolling = $(T_2 + W_2)$ 2. K = P_2/P_1 ratio of perimeter before rolling to permieter after rolling.

TABLE IV.—*Wire Flattening Test, Square to Flat.*

Successive reduction on M.S. (bright drawn) rolls, 10in. diameter, 29 R.P.M. ·252in. square. P_0 = perimeter before rolling = 1·008in.

Pass No.	T_1.	T_2.	W_2.	% red'n. r.	Total % red'n. R.	% spread s.	Total % spread, S	Ratio S/R.	P_1.	P_2.	K P_2/P_0.	k P_2/P_1.
	in.	in.	in.									
1	·252	·209	·270	17·1	17·1	7·15	7·15	·418	1·008	·958	·945	·945
2	·209	·186	·284	11·0	26·2	5·20	12·7	·485	·958	·940	·930	·980
3	·186	·160	·302	14·0	36·5	6·35	19·85	·545	·940	·924	·915	·985
4	·160	·138	·320	13·75	45·3	5·96	27·0	·595	·924	·916	·905	·990
5	·138	·122	·336	11·6	51·5	5·00	33·3	·648	·916	·916	·905	1·000
6	·122	·106	·354	13·1	58·0	5·35	40·5	·700	·916	·920	·912	1·005
7	·106	·089	·374	16·05	64·7	5·65	48·5	·750	·920	·926	·917	1·005
8	·089	·072	·404	19·1	71·5	8·00	60·5	·845	·926	·952	·945	1·030
9	·072	·054	·441	25·0	78·7	9·15	75·0	·950	·952	·990	·980	1·040
10	·054	·039	·483	27·8	84·5	9·55	91·7	1·090	·990	1·044	1·035	1·060
11	·039	·033	·496	15·4	87·0	2·70	97·0	1·115	1·044	1·058	1·050	1·015

T_1 = thickness before pass. T_2 = thickness after pass. W_2 = width after pass. P_0 = original perimeter before rolling. P_1 = perimeter before pass. P_2 = perimeter after pass. K = P_2/P_0. k = P_2/P_1.

TABLE V.—*Wire Flattening Test, Square to Flat, Successive Reductions, Brass Bar.*

Rolls 10in. diameter, 29 R.P.M., ·505 square. P_0 = 2·02.

Pass No.	T_1	T_2.	W_2.	% red'n. r.	Total % red'n. R.	% spread s.	Total % spread S.	Ratio S/R.	P_1.	P_2.	K P_2/P_0.	k P_2/P_1.
	in.	in.	in.									
1	·505	·387	·575	23·4	23·4	13·9	13·9	·595	2·02	1·924	·955	·955
2	·387	·340	·600	12·15	32·7	4·35	18·85	·574	1·924	1·880	·930	·975
3	·340	·276	·635	18·85	45·4	5·84	25·8	·568	1·880	1·822	·905	·970
4	·276	·183	·735	33·7	63·8	15·75	45·5	·715	1·822	1·836	·908	1·001

T_1 = thickness before pass. T_2 = thickness after pass. W_2 = width after pass. P_0 = original perimeter before rolling. P_1 = perimeter before pass. P_2 = perimeter after pass. K = P_2/P_0. k = P_2/P_1.

TABLE VI.—*Wire Flattening Test, Rectangular to Flat.*

Successive reductions, rolls 10in. diameter, 29 R.P.M., ·504 by ·252 bright-drawn steel. P_0 = 1·512.

Pass No.	T_1.	T_2.	W_2.	% red'n. r.	Total % red'n. R.	% spread s.	Total % spread S.	Ratio S/R.	P_1.	P_2.	K P_2/P_0.	k P_2/P_1.
	in.	in.	in.									
1	·252	·201	·533	20·2	20·2	5·75	5·75	·285	1·512	1·468	·975	·975
2	·201	·175	·552	12·9	30·6	3·57	9·5	·310	1·468	1·454	·965	·990
3	·175	·150	·572	14·3	40·5	3·62	13·5	·334	1·454	1·444	·955	·995
4	·150	·131	·589	12·7	48·0	2·97	16·9	·352	1·444	1·440	·952	·997
5	·131	·114	·604	13·0	55·0	2·55	19·8	·360	1·440	1·436	·950	·997
6	·114	·100	·617	12·3	60·5	2·15	22·4	·370	1·436	1·434	·948	1·000
7	·100	·085	·635	15·0	66·5	2·84	26·0	·391	1·434	1·440	·952	1·005
8	·085	·066	·661	22·4	74·0	4·1	31·2	·422	1·440	1·454	·965	1·007
9	·066	·047	·699	28·8	81·5	5·7	38·7	·475	1·454	1·492	·988	1·025
10	·047	·035	·723	25·6	86·0	3·43	43·5	·506	1·492	1·516	1·005	1·015
11	·035	·029	·744	17·15	88·5	2·9	47·5	·537	1·516	1·546	1·025	1·020

T_1 = thickness before pass. T_2 = thickness after pass. W_2 = thickness after pass. P_0 = original perimeter before rolling. P_1 = perimeter before pass. P_2 = perimeter after pass. K = P_2/P_0. k = P_2/P_1.

have any very serious influence on the amount of spread, the deduction of a general rule would seem almost an impossibility.

The collected results of trials are given in Tables I. to VI., and, as it is usual to estimate reduction in thickness and also spread as a percentage of the original thickness and width respectively, the first obvious step is to show some definite relation, if such existed, between per cent reduction and per cent. spread.

With a thickness T_1 before rolling and T_2 after the pass, per cent. reduction is given by the expression

$$\frac{T_1 - T_2}{T_1} \times 100.$$

Similarly, with a width W_1 before rolling and a width W_2 after—

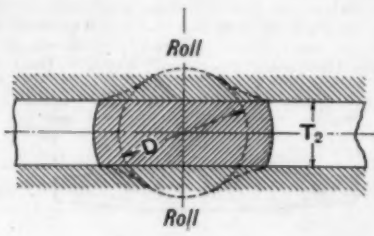
$$\text{Per cent. spread} = \frac{W_2 - W_1}{W_1} \times 100.$$

The relation between these two quantities is the ratio—

$$\frac{(W_2 - W_1)\ T_1}{(T_1 - T_2)\ W_1},$$

which from the experimental figures is a variable quantity, and while an empirical expression can be obtained which will give approximately this relation, calculation based on it would be correct only between wide limits.

The original trials were intended to investigate the question of spread in the case of flatteniag round wire or rod to flat strip, and the majority of the figures obtained refer to this particular form of reduction, but by reference to Fig. 1 and Fig. 2, the first reduction in thickness from the circular section is a somewhat



1ST. PASS FLATTENING ROUND SECTION

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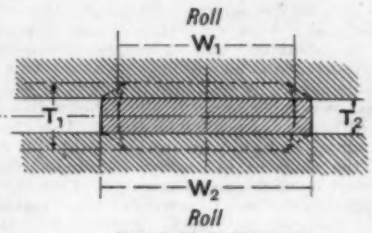
FIG. 1



2ND. PASS FLATTENING ROUND SECTION

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FIG. 2

different case to that presented by any further reduction on the same metal. As might be expected from consideration of the forces acting on the metal, the reduction from round to flat results in a greater proportionate spread than with the further reductions on the same piece, which merely result in decrease in thickness without any appreciable change in the shape of the section. We have therefore to consider two variations in the same process:—(1) Effecting varying per cent. reduction in thickness on the circular section in one pass; and (2) similar reductions in two or more passes.

With regard to the first case, Table I. gives results from a number of trials, eighteen in all, each carried out on a different sample, arranged in order of per cent. reduction in thickness. The reductions given in the fifth column range from 7 per cent. to 62½ per cent., each reduction being taken at one pass through the rolls. Column 6 gives the corresponding per cent. spread, and the seventh column the ratio per cent. spread per cent. reduction; these figures are plotted by curve in Fig. 3.

The size of rolls used, the roll speed and class of material flattened is also noted. It should be mentioned that while many of the tests were personally supervised by the writer, who checked the dimensions

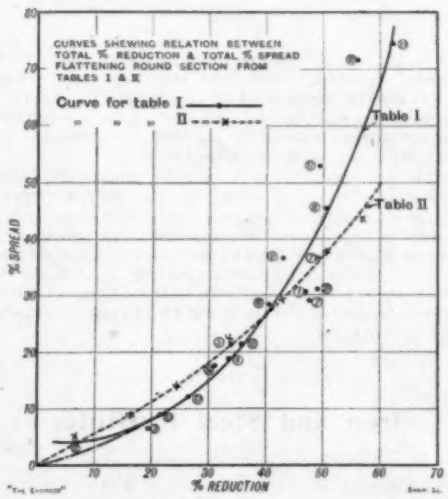
CURVES SHEWING RELATION BETWEEN TOTAL % REDUCTION & TOTAL % SPREAD FLATTENING ROUND SECTION FROM TABLES I & II
Curve for table I
II
Table I
Table II
% SPREAD
% REDUCTION
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FIG. 3

of the wire before and after the pass, others were reported by assistants, and the accuracy of the dimensions W_2 for width after pass cannot in all cases be guaranteed within fine limits, especially as the reading of a micrometer may differ to the extent of ·001in. with the individual. Generally it will be seen that there is a regular increase in per cent. spread with the reduction, and while some of the tests, as seen from the curve, give inconsistent results, the divergence from regularity does not appear to be accounted for by any difference in material, size of rolls, or speed.

The curve traced agrees very closely with tests 6, 3, 12, 13, 14, 4, 15, 16, 8 and 19, and four or five other tests are not far off the line; those which agree most closely are all steel samples, roll diameter about the same, but a speed variation of 29 to 40 revolutions per minute does not have any appreciable influence. Two samples of copper, tests 0 and 20, are divergent but in opposite directions, and are no more erratic than other tests on steel such as 1, 2 and 17.

The ratio of per cent. spread to per cent. reduction is seen generally to increase with the increase in reduction, and if the first test in Table I.—test No. 6—

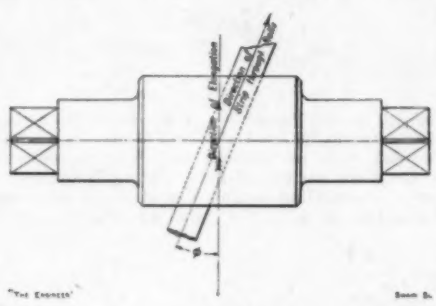

FIG. 4

is ignored, as it is markedly inconsistent, this ratio increases fairly regularly from ·333 at 19·2 per cent. reduction to 1·24 at 57·5 reduction.

In view of the fact that the figures recorded in Table I. are taken from a number of separate tests unconnected with one another, carried out at different times, on varying diameters, materials, &c., the results are really remarkably consistent.

It is also as well to bear in mind that a variation of spread with any reduction in thickness would result if the sample were not entered exactly with its longitudinal centre line at right angles to the axis of the roll. This is explained by Fig. 4, from which it is clear that any increase in the angle φ would result in increased spread.

The second case of reduction from round to flat, namely, successive reduction on one sample of metal is illustrated by results given in Table II. Here a length of mild steel previously drawn to a diameter of .213in. diameter is reduced in a series of seven passes to a final thickness of ·092, being a total reduction of 57 per cent., the successive reductions being approximately the same percentage of the thickness before the pass.

In this case it is obviously necessary to compare, not the per cent. reduction with per cent. spread for each pass, but the total per cent. in reduction and spread. The amount of reduction in thickness and increase in width for each pass being referred to the original dimensions of the sample. See curve, Fig. 3.

The first reduction from round to flat shows a greater spread in relation to reduction in thickness than the following passes on the flattened strip, the ratio for the first pass in Table II. being ·595, in the second pass the ratio drops to ·546, and after this there is a gradual and fairly regular increase of spread, the ratio growing from ·546 to ·762.

These ratio figures are plotted by curve in Fig. 6. The curve for spread and reduction—Fig. 3—based on successive reductions follows a somewhat different line from that of the curve for independent tests from Table I.

Up to about 40 per cent. reduction in thickness the relative spread shown by curve for tests in Table II. is very close to that given by curve for Table I., but slightly greater; after 40 per cent. the curves diverge the spread in the case of successive reductions increasing very much more slowly than with independent

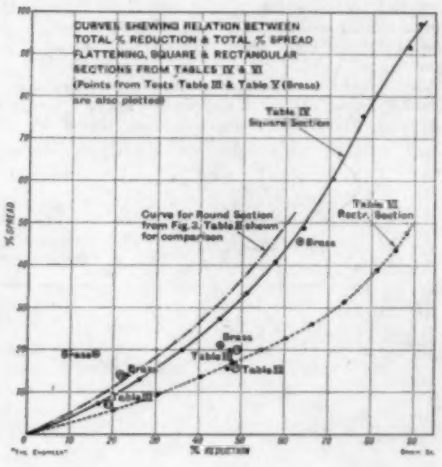
CURVES SHEWING RELATION BETWEEN TOTAL % REDUCTION & TOTAL % SPREAD FLATTENING, SQUARE & RECTANGULAR SECTIONS FROM TABLES IV & VI
(Points from Tests Table III & Table V (Brass) are also plotted)
Table IV Square Section
Curve for Round Section from Fig. 3, Table II shown for comparison
Table VI Rectr. Section
Brass
Brass
Brass
Table III
Table III
% SPREAD
% REDUCTION
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FIG. 6

reduction, flattening in one pass from round to flat. This proves a fairly well-known fact that, with heavy reduction, the spread from round to flat is relatively greater than for further reductions on metal already flattened.

The additional tests shown by Tables III. to VI. are not as extensive as with the flattening of the round section, but are sufficient to show the very interesting difference due to the shape of the initial section.

Table III. gives independent examples of reduction from square to flat with reductions varying from 17 to 47 per cent.

Table IV., also referring to the rolling of square section, gives figures for successive reductions on ·252 square steel, from 17 per cent. to 87 per cent. total reduction.

Table V. also successive reduction on square brass bar ·505in. square.

Table VI., successive reductions on rectangular steel—ratio of width to thickness 2/1. Reduction up to 88 per cent.

In the cases of reduction from square, the tests given in Table III. are too few in number, and the

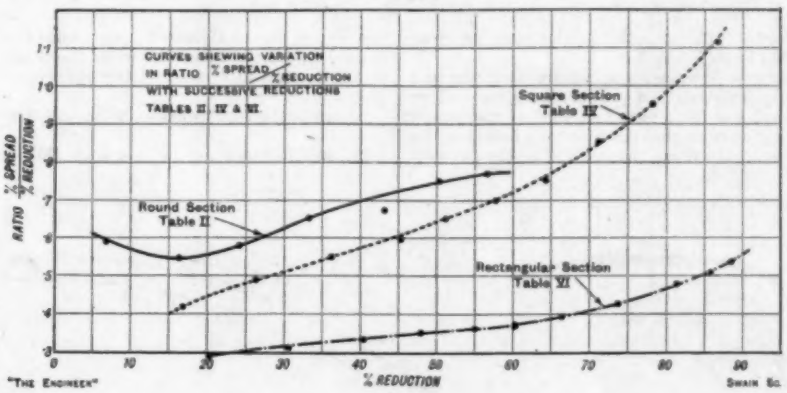
CURVES SHEWING VARIATION IN RATIO % SPREAD / % REDUCTION WITH SUCCESSIVE REDUCTIONS TABLES II, IV & VI.
Square Section Table IV
Round Section Table II
Rectangular Section Table VI
RATIO % SPREAD / % REDUCTION
% REDUCTION
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FIG. 5

figures too erratic to allow the plotting of a reliable curve, but the successive reductions in Tables IV.—plotted in Fig. 5—and V. are fairly consistent; in the former case, the ratio $\frac{\text{total spread}}{\text{total reduction}}$ per cent. increases from ·418 at 17 per cent. reduction to 1·15 at 87 per cent., the increase being very regular, and even the figures for the brass bar from Table V. are quite reasonably close to those from Table IV., in spite of the difference in the metal; the ratios are, however, not so consistent.

Generally, if comparison is based mainly on tests from Tables II. and IV., it is fairly clear that when rolling from the square section the per cent. spread at any given reduction is less than that at the same reduction on the round section.

With rectangular section—Table VI.—the ratio of spread to reduction is still less than that in the case of the square section, the ratios increasing from ·285 at 20 per cent. reduction to ·537 at 88·5 per cent.

TABLE VII.—*Ratios* $\frac{Total\ \%\ Spread}{Total\ \%\ Reduction}$

% reduct'n approx.	Round to flat, Table I.	Round to flat, Table II.	Square to flat, Table III.	Square to flat, Table IV. and V.	Rect. to flat, Table VI.
20	·420	—	—	·418	·285
25	·445	·575	·595	·485	—
30	·575	·656	—	·574	·310
35	·605		—	·545	—
40	·705	·672	—	—	·334
45	·855	—	—	·595	—
50	·90	·745	—	·648	·352
55	—	—	—	—	·360
60	1·19	·762	—	·700	·370
65	—	—	—	·750	·391

Roughly these ratios for different sections are as given by Table VII., and curves in Fig. 6.

At any particular reduction, say, about 50 per cent., the comparative ratios are ·745 for round section, ·648 for square, and ·352 for the rectangular bars. In the case of round and square, that is where the initial width and thickness are equal, the difference in ratio is not great and the slightly greater spread with the round section is obviously due to the greater spreading action of the rolls on the circular cross-section. See Figs. 7 A and B.

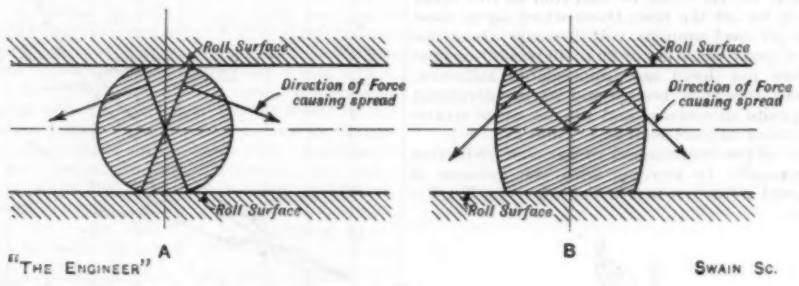


FIG. 7

The difference between the square and the rectangle is very marked, the proportion of spread for the latter being a little over half that of the former, and it is fairly obvious that the wider the initial section in relation to its thickness the less will be the per cent. spread for any given reduction; moreover, roughly the actual amount of spread is almost the same with a bar of width 2 and thickness 1, as that for a bar 1 square, consequently the per cent. referred to as the original width is less in the former than in the latter case by about 50 per cent.

This would appear to be due to the restraining effect of the friction between the rolls and the surfaces of the metal in contact.

Referring to Fig. 7 at A, rolls are shown flattening a round section, and it is obvious that the spreading is to a great extent unrestrained by friction. At B the action on a square section gives a relatively greater surface in contact, the friction on which tends to confine the spread; this action is intensified when flattening a rectangular bar—2/1 ratio width to thickness. The pressure exerted by the rolls per unit area of surface in contact is the same as in the case of the square section, but the contact area is twice as great. Consequently, the spreading from the vertical centre line is opposed by nearly twice as great a frictional resistance; at the extreme edges the spread is unrestrained, but at points nearer the centre the resistance is increasingly greater. This is perhaps made clearer by reference to Fig. 8, in which the flattened section between the rolls is shown divided into vertical laminæ of negligible width. The whole section is subjected to a pressure F, exerted by the rolls over the surfaces in contact, the main effect of the pressure being to cause elongation of the metal at right angles to the axes of the rolls, as will be seen in the side elevation in Fig. 8. Extension in this direction is aided by the rotation of the rolls, which causes a frictional force $P = F\mu$, where μ is the co-efficient of friction between the rolls and the surfaces in contact. Spreading takes place at the same time, but this is opposed by the friction between rolls and metal, this frictional resistance acting in the direction at right angles to A B, shown by arrows.

The extreme lamina 1 at C and D may be assumed to spread freely to the left and right respectively, but the next element 2 in spreading is obliged to move the preceding lamina 1 against opposing friction, and so on until the layers 10 on either side of the centre line A B have to overcome the resistance caused by all the layers between them and the edges of the section at C and D, the opposing force being $\frac{F}{2}\mu$, and as the total pressure F is necessarily increased with any increase in the width of the section it is clear that the width may conceivably be increased to such an extent that the frictional resistance to spread is sufficient to prevent any widening of the innermost layers. Consequently, the per cent. spread in wide section is, as is also shown by the tests, less than in the case of narrower.

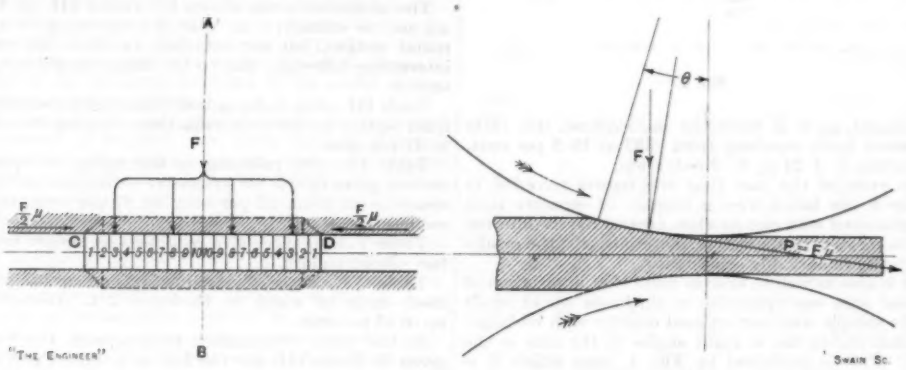


FIG. 8

In addition, the tendency clearly shown above, for the spreading of sections of appreciable width in proportion to their thickness, to spread unequally across the width of the section, has a most important influence on the rolling of metal, for with unequal spread unequal elongation will result, and referring again to Fig. 8 maximum elongation will correspond to minimum spread, and will occur on the centre line A B of the section. This elongation will decrease from this line outwards until it reaches a minimum at C and D, where spreading of each unit of width is the greatest. This effect is well known to occur, especially when rolling hard metals to finer gauges, where the high tensile strength prevents the stretching of the edges to keep pace with the greater elongation of the centre, and the result is shown by Fig. 9, the strip buckling across its width to the curve form shown at A, and curving in its length, with its longitudinal centre line of width on the outside of curve—being the greater length—as shown at B. Even with softer metals, where equalisation of elongation takes place by stretching, another defect is developed, namely, the reduction of thickness at the edges of the strip, resulting in the very common trouble with strip which is not uniform in thickness across its width. As shown exaggerated in Fig. 10, this trouble has generally been attributed to the bending of the rolls, and their greater deflection at the centre; but there is no doubt that in many cases this view is incorrect, and that unequal spreading is the real cause. Fortunately, the remedy for both causes is the same, namely, the use of a cambered roll, as shown exaggerated by Fig. 11. This has the effect of giving a slightly greater pressure in the centre of the strip, and of causing spread to take place with greater uniformity from the centre to the edges. It will also be seen from Fig. 7 that by the "wedge" action of the rolls, spreading force is greater when the contact surface is small in relation to the thickness of the section, i.e., as in the round section.

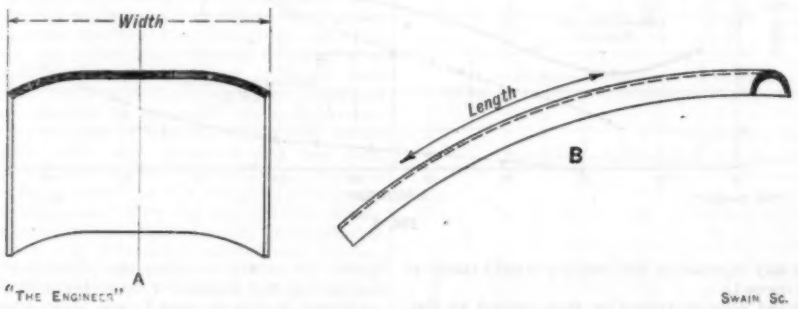


FIG. 9

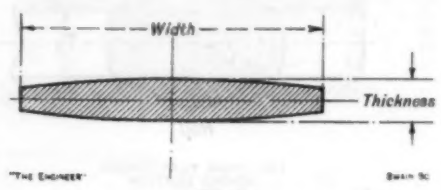


FIG. 10

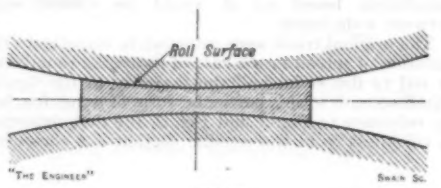


FIG. 11

This question is perhaps scarcely within the scope of this article, and it would occupy too much space to give a more detailed explanation, but it is necessary to emphasise the practical importance of spread, not only in wire flattening and similar work, on narrow sections, but in strip rolling generally, and as far as the writer is aware, this cause of the defects in rolled strip, as indicated in Figs. 9 and 10, has not previously been pointed out.

Iron and Steel Institute.

No. I.

THE annual meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers on June 3rd and 4th, under the presidency of Sir Peter Rylands. The first business was the reading of the Report of the Council:—

REPORT OF COUNCIL.

During the past year sixty-five new members and eight associates were elected, and six associates were transferred to membership. The total membership on December 31st, 1925, was therefore as follows:—

Patron	1
Honorary members	11
Life members	78
Ordinary members	1899
Associates	33
Total	2022

Fifty-nine members and two associates resigned their membership during the year, and the names of thirty-seven members were removed from the register owing to the non-payment of their subscriptions.

The income of the year under review, exclusive of the Carnegie Scholarship Fund and of the interest received from the Special Purposes Fund, was £7952, and the expenditure for the year was £8084.

The Bessemer Gold Medal for 1926 was awarded to Sir Hugh Bell.

Sir Peter Rylands, in making the presentation, said that the recipient was one of the outstanding

figures in the iron and steel industry of Great Britain, having followed in the footsteps of his father, Sir Lowthian Bell, who was the pioneer of the iron industry on the North-East Coast. It was of interest to recall the fact that Sir Lowthian Bell received the Bessemer Medal in the year 1874, and was the first member of the Institute to whom it was awarded. Sir Hugh Bell was one of the very few remaining original members of the Institute, and had acted as President. He had also taken a large and active part in public life. He was an original member of the Industrial Council for the settlement of labour disputes and had been chairman of the Tees Conservancy Commissioners since 1903. He was a director of the London and North-Eastern Railway and other important undertakings. Sir Hugh Bell acknowledged the presentation in appropriate terms.

Sir Peter Rylands then delivered his presidential address, an abstract of which we gave last week.

It was announced that Mr. Illtyd Williams, who has just retired from the honorary treasurership, had presented to the Institute the sum of £3000, the interest on which is to be devoted to prizes for papers of practical interest. The prizes will only be awarded to British subjects employed in British works, and a condition is that the recipient must not occupy any position higher than that of manager of a technical department.

Heterogeneity of Steel Ingots.

Dr. W. H. Hatfield presented the report on "Heterogeneity of Steel Ingots," which has been prepared by a sub-committee of Committee V. of the Institute, of which Dr. Hatfield is chairman, and the other members Mr. T. P. Colclough, Mr. W. J. Dawson, Mr. J. H. S. Dickenson, Mr. A. P. Hague, Mr. E. F. Law, Mr. S. A. Main, Mr. T. M. Service, and Mr. J. H. Whiteley. An abstract of the report was given in our issue of May 21st.

Introducing the discussion on the report, Mr. J. H. S. Dickenson, a member of the sub-committee, referred to the tendency to use larger forgings and to the manner in which the specifications of engineers had been tightened up during recent years. It was recognised, however, that it was by no means an easy matter to state whether any particular forging possessed all the qualities required, and was fit for use. The main object of the report was to direct attention to the very considerable variation which could exist in large steel masses, and to suggest to engineers that they must get out their designs with that fact before them. Many engineers were, he feared, in the habit of designing structures of various kinds to give extraordinarily high performance, on the assumption that the steel used was homogeneous in character. It would be something in the nature of a miracle to produce a perfect forging, and it was necessary for engineers to understand the difficulties confronting steelmakers, and the kind of thing which might happen from causes beyond their control.

Mr. E. H. Saniter having referred to the manner in which the investigation came to be undertaken by a sub-committee of Committee V., pointed out that although the ingots dealt with might be regarded as the average production of the works in which they were made, they were better than average steel ingots made by different methods. He agreed with the main lines of the report. The heterogeneity of steel ingots was due to differences of crystallation, and to the segregation of metallic and non-metallic compounds. It must be borne in mind, however, in looking at some of the results that sulphur printing, which was the method adopted, had a tendency to exaggerate the defects it revealed. The statement, that the more rapid the freezing the less heterogeneity was likely to be set up, required qualification. The chill crystals which were very rapidly formed squeezed carbides, sulphides and phosphides into the interior of the metal, which therefore became more segregated. He had seen in small test ingots of 1in. diameter, which became solid in a minute or two, a serious state of segregation. With reference to silicon and manganese, there was no material evidence in the report that these elements or their metallic compounds segregated. They were generally added at a late stage of the process of making steel, and in the percentage in which these elements were present in the ingots with which the experiments had been carried out, they were in such a state of combination, and the melting points were high enough, to prevent ejectment in the liquid form as the steel solidified. It was shown in the report that there was a much greater segregation of sulphur than of manganese, and it was evident that sulphur and manganese did not segregate together. It was clear, however, that the two elements were chemically combined, and it was to be assumed that at or about the temperature of solidification the manganese was able to rob the iron of the sulphur. It was well known that at the temperature of molten pig iron the manganese was combined with the sulphur, and was able owing to its insolubility to rise out of the metal. That was not, however, the case with molten steel, and he was not therefore able to accept the views on this subject put forward in the report.

Sir Robert Hadfield commented on the fact that the whole of the important work dealt with in the report had been done by the private manufacturer, without any kind of Government aid. While the investigation left but little room for criticism, it appeared to him that insufficient attention had been paid to the special feature of soundness in the material. It was necessary to make sure of the soundness of the steel before pouring. No matter what process was employed, there was one general law, namely, that molten steel, specially when cast in large masses and allowed to solidify, was in some cases liable to show a certain amount of unsoundness, and often more so than was generally supposed. It was quite possible for the material to appear sound when subjected to ordinary tests, but if poured into a simple greensand mould—as was shown by specimens he had had brought to the meeting for the information of those present—the steel might reveal very bad qualities.

Mr. Cosmo Johns said that while presenting a number of facts, the Committee, in drafting the report, had refrained from putting forward explanations. The report provided material for careful study. He would submit a statement in writing after he had had more time to give to the subject. A point which should be emphasised was that the ingots placed at the disposal of the Committee represented the best class of steel which could be produced. Engineers who read the report showing the heterogeneity of these high-class ingots need not be alarmed for the safety of the structures in which the steel was employed. The investigation had, however, given fresh proof that steel was a highly complex structure, and that its production in large masses which would give satisfactory results in service was not a simple task.

Sir William Ellis thought that the information given in the report was of greater value, perhaps, to engineers than steel makers. The Committee had put before members the laws of nature as they affected the manufacture and the settling of large masses of steel, and it was common knowledge that metallurgists had sought to discover methods by which those laws could be controlled. The Whitworth and the Harmet processes were examples of what had been achieved. Steel manufacturers were still doing their best to cope with the difficulties attending the production of homogeneous material.

Mr. C. E. Stromeyer referred to failures in boilers which had come under his notice, and to the influence of the phosphorus and nitrogen contents of the steel. Engineers were inclined to think that ·06 per cent. of phosphorus should be the limiting figure for that impurity in steel, but the report showed that an ingot might contain patches with much higher percentages of phosphorus, and yet withstand service conditions. The boiler failures which had come under his notice, some after many years' working, were due in a majority of instances to phosphorus, nitrogen or caustic soda.

Mr. H. Brearley said that the Committee could not have done its work but for the willingness of the steel makers to face the cost of supplying the ingots. Segregation was a complicated problem, but the thing which stuck in the throats of engineers, and was a source of trouble and anxiety to steel manufacturers, was what might be termed "line" segregation. He did not agree with some of the statements made in the report, but noted that nobody would accept individual responsibility for Section IV. of the report, which opened up a general discussion on the phenomena associated with segregation in steel ingots.

Dr. W. Rosenhain welcomed the report as a fine example of co-operative research. It raised many questions of interest. There was a suggestion that the conditions which engineers sought to impose on steelmakers were at times unreasonable. He had no doubt that the requirements of inspectors were occasionally unreasonable, but the steelmakers must look at the question from the standpoint of the engineer. The crux of the whole problem was the admission that the steel manufacturer lacked control over some stages of the process of making steel. The knowledge required to give control over the phenomena recorded in the report would have to be obtained. It was suggested that some knowledge could be derived from the behaviour of certain binary and ternary systems, but he deprecated any idea of that kind being adopted. What was required was more knowledge of the changes which occurred in the properties of liquid iron and liquid alloys prior to reaching the freezing point. There was also the question of the influence of sulphur, which ought to be based on knowledge, and not left to inference. Another point was the part played by gases in liquid steel, concerning which very little was known. It was obvious that while excellent work had been done there was need for further and more detailed investigation than was possible in the research dealt with in the report of the Committee.

Dr. C. H. Desch accepted the facts set out in the report as authoritative. In spite of the defects in the ingots dealt with from the standpoint of the want of homogeneity, he had been impressed by the great improvement which had been made in the casting of ingots during recent years. Segregation troubles were less serious and the ignorance as to what occurred during the solidification of steel ingots was not so great as this report would appear to suggest. The compilers of the report had referred to the work done by other investigators and a mass of literature on the subject was available. More definite information was, however, required on many points. It was difficult to dissociate the statements made in Section IV. of the report from the more practical part of work of the Committee, but he was not able to accept some of the theoretical statements. It was stated, for example, that at a certain stage in the cooling of the freezing ingot, the temperature of the remaining liquid would approach the freezing point, and would become very viscous. That was not the case; the viscosity under those conditions would be of a small order.

Mr. T. H. Turner dealt with the subject from the point of view of the metallurgist who was called upon to defend the interests of the user. It had long been known that the analyses of large ingots would show variations, but it ought to be possible for the metallurgist to say whether the ingot was suitable for certain purposes. He did not agree that the sulphur print exaggerated defects when the users' interests were in question. The main cause of failure was a bad form of segregation which might not be revealed by chemical analysis, but would be shown on a sulphur print. As far as carbon and silicon were concerned, analysis was reliable, but it was not a safe method to use when dealing with non-metallic inclusions. It should not be overlooked that the report only dealt with carbon steels, and it was known that in certain alloy steels heterogeneity assumed a more serious form. Nor did the report take into account the influence of grain size in the finished article, which had a great effect on the physical properties of the material. It would be desirable to have more information with regard to the effect of flow, on what happened during pouring, and the influence exerted by pouring from the bottom. He put forward the suggestion that the density test for steel might be used with advantage. The steel which gave the highest figure for density should be the soundest.

Dr. S. W. Smith referred to work on segregation in non-ferrous metals with which he had been associated. In non-ferrous metallurgy the form of segregation met with was that known as liquation. The peculiarity was that the direction in which the constituents segregated was exactly the reverse of that which would be expected from a consideration of the equilibrium diagram. The apparent contradiction of theory by fact had been attributed primarily to the influence of the temperature gradient from the chilling surface to the interior. Professor Carl Benedicks had drawn attention to the same condition in determining the distribution of the constituents in steel and cast iron, and the present report confirmed his work. Curiously enough, no attempt was made to apply liquation effects to the results which had been obtained, although almost any of the examples quoted could be taken to illustrate the influence of liquation during the solidification of steel.

Dr. D. Hanson said that the statement in the report that rapid cooling tended to suppress segregation, owing to the lack of time for complete separation of the two phases, was contrary to general experience. Segregation occurred under conditions of rapid cooling, but was of a character which was only disclosed when the metal was examined microscopically.

Mr. E. A. Atkins took up the point that the ingots examined by the Committee were rather better than average steel ingots. If that were so, it would be interesting if some results could be given for ordinary ingots from various steel works, and also, if possible, for badly made ingots. With reference to sulphur and manganese, it was curious that the sulphur content might be four times more in one part of an ingot than another, with very little change in the manganese. He believed that a large part of the sulphur was in the form of iron sulphide, which put the steel in a dangerous state and might explain some of the breakages in the material used for wire drawing operations. It was a matter for regret that the work of Rolls on the influence of sulphides had not been followed up. Additional information would prove of great value to steelmakers at the present time. He was disappointed that the Committee had not made a definite attempt to interpret the facts set out in the report, but the differences of opinion were apparently so acute that it was decided not to publish anything. It would have been better if individual members of the Committee had been allowed to present their views, and give some indication to manufacturers of the methods by which heterogeneity in steel ingots could be reduced to a minimum.

Mr. T. M. Service, referring to the remarks of the last speaker, said that the only difference between the ingots placed at the disposal of the Committee and ordinary steel ingots as made for ship and boiler plates was that they were of pipe steel. A question had been asked whether the sulphur prints represented the actual centre of the ingot. Most of the ingots were machined half an inch off the centre line, and taken off half an inch. In most instances blow-holes existed, and there was distinct weakness down the centre line. Another point was that of falling crystallites, and he was able to say that no evidence of it was found. There was very little segregation of manganese and silicon, and considerable segregation of carbon, sulphur and phosphorus. The facts had been set out in the report, and the task which now had to be undertaken was to discover the law which governed the phenomena. It seemed clear that the type of segregation which had been examined was not influenced by the carbon content, by the moulds used or the method of manufacture, basic or open-hearth or electric furnaces. Other factors which now required consideration were casting temperatures, speed of cooling of mass and temperature difference between outside and centre. The latter conditions were most

difficult to estimate and control, but might be mainly responsible for the degree of heterogeneity in steel.

Dr. W. H. Hatfield, in replying briefly to some of the many points raised, expressed disappointment that the discussion had not included data from steel works other than those from which ingots had been supplied to the Committee. It had not, unfortunately, been possible to examine any steel which had been treated by the Harmet or other pressure processes. The big 172-ton ingot, whatever its degree of heterogeneity had produced a forging which had given a very good account of itself, and that was evidence of some importance. In the near future the Committee would hold a meeting and consider very carefully all the points which had been raised.

On the motion of the President, the members of the Committee were warmly thanked for the work done and the report presented.

Silicates in Steel Ingots.

Mr. J. H. S. Dickenson then presented "A Note on the Distribution of Silicates in Steel Ingots," an abstract of which is given below :—

It is now agreed that every ladle of steel "deoxidised" by the addition of silicon and manganese, or, indeed, any other deoxidiser, contains a greater or lesser, but always appreciable amount of the results of the reaction between the dissolved ferrous oxide and the "additions," in the form of exceedingly small globules of a silicate, most of which are too small to rise to the surface in the time available. Undoubtedly some separation by rising to the surface does occur, not only in the furnace and during the waiting time in the ladle, but also in the mould, if the ingot be at all large. Against this must be set the absorption of oxygen by the stream of metal during teeming, which produces fresh ferrous oxide to react with dissolved free silicon and manganese.

There are, of course, other sources of non-metallic or slaggy impurity than the inevitable deoxidation products: but the evidence goes to show that although such extraneous slaggy matter does sometimes lead to trouble, and should always be avoided as far as possible by cleanly methods and careful selection of refractory materials, the main and predominant source of the entangled non-metallic matter, which is manifested in the form of inferior transverse test results, "slag specks," and "sandy patches," is to the result of a reaction which cannot be avoided if sound steel free from "blow-holes" is to be produced.

In the casting of a large ingot some of the silicate globules coalesce into relatively large masses which more readily escape to the surface and are floated upwards as the steel rises in the mould. This is all to the good, but unfortunately the currents set up by the stream descending from the ladle tend to carry these patches of "cream" towards the mould wall, where some may stick. If this happens, and the steel rises over the anchored slaggy matter, some of it may break away and attempt to regain the surface, but it will probably be trapped in the solidifying chill wall, to be discovered at a later stage when the forging is being machined. Such defects, of which every maker of large ingots in the world has painful experience, may sometimes occur, as a matter of chance or accident, anywhere in the outer portions of a large ingot, but it is not these accidental and occasional enclosures, but the normal scattered and finally divided matter, with which this paper is primarily concerned.

With the purpose of studying the distribution of the scattered particles within the frozen steel, two ingots, both made of acid open-hearth nickel-chromium steel, were taken. Both were cast into octagon chill moulds, wider at the upper end, and provided with refractory linings for the feeder head. One was relatively small, weighing 15 cwt., with a diameter of 15in. at the top of the body, and was bottom-cast in a group. The other was much larger, weighing 12 tons, with an upper end diameter of 36in., and was, of course, top-cast.

When cold, both ingots were longitudinally half-sectioned; a complete slice, 2in. thick, including head and body, was cut from the smaller, but in the case of the larger, the head was first parted off just below the shoulder, and the body was cut in two to provide a half-section exactly across the central axis.

Despite the very considerable difference in the mass of the two ingots, the principal structural features are very similar, and accord with the internal arrangements of most of the nickel-chromium steel ingots which the author has examined. There are the same external columnar walls, built up of chill crystals, having a decided upward inclination, a light-etching central pyramid of free crystals, resting on the bottom floor of chill crystals, and extending upwards well towards the upper end of the body, and an annular zone of free crystals which etch differently from those of the lower pyramid.

Samples for estimation of silicates and general chemical analysis were then removed from a number of points on each ingot section, those from the larger ingot being trepanned out.

The two ingots agree in showing the highest silicate content at or near the central axis near the bottom end, and within the lower part of the central pyramid of free crystals. In both ingots samples taken from the columnar walls everywhere show a fairly uniform distribution of silicate, except one result near the bottom of the ingot, which is probably due to the trapping of some separated slaggy matter.

In both ingots, also, the amount of silicate steadily falls on moving up the central axis from the region of maximum content near the bottom. In the case of the small ingot, it actually falls to a minimum at the place of maximum sulphur, phosphorus, and carbon segregation in the head just below the pipe cavity. No doubt the same result would have been reached in the larger ingot had the head been sectioned.

There is, however, one very striking feature shown by the 12-ton ingot, not to be observed in the smaller, this being the perfectly definite indication of an annular zone, in the upper half of the ingot, where the silicates are present in greater quantities than in the columnar wall on the outside or in the core within.

This is clearly brought out by the zoning on the right side of the diagram, where that part of the ingot containing over 0·015 per cent. silicates is enclosed by the lines A A–B B. On the left of the ingot section the main structural divisions revealed by etching are lightly indicated.

These observations clearly prove, considered as a whole, that there has been an ordered arrangement of the silicate particles in each of these two ingots, which has led to a striking similarity in the distribution. This is the more noteworthy in view of the considerable disparity in size, and of the fact that the smaller ingot was bottom-cast while the large one was top-cast.

The evidence now presented amounts, in brief, to this—that in each of a number of ingots, all made of carefully killed or deoxidised steel for the manufacture of special forgings, the percentage of slaggy matter in the form of small globular silicate particles rose to a maximum in the central lower part, precisely where carbon, sulphur and phosphorus were each reduced to a minimum by segregation.

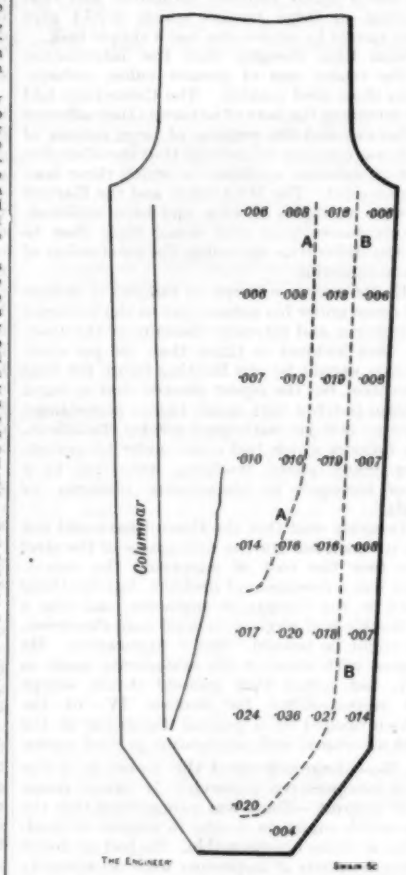
This applied to quite small as well as to very large ingots, to ingots of carbon, nickel, and nickel-chromium steels, to top-cast and bottom-cast ingots, and, it should be added, to large ingots made by other firms. It was further found that in this region, which lay a little above the floor of columnar crystals, and within the pyramid of light-etching free crystals erected upon this floor, the silicates were not only greater in amount, but the separated residues included a considerable proportion of globules which were larger than those normally to be found in any other part of the ingot.

As the globules of slaggy matter suspended in the fluid steel should escape more readily as their size increases, the presence of such globules near the central axis, and a little above the bottom, must be due to their being carried to, or held in, that position by the solidifying steel. It was supposed at one time that this congregation of large slaggy particles near the bottom end might be connected with the stream of metal from the ladle, which probably produces a far-reaching downward current, even when a large mould is nearly full; but the fact that a small bottom-cast ingot showed the same effect as larger ingots, not quite so clearly, but still unmistakably, disposes of this, at any rate as the sole explanation.

Some years ago Stead suggested that during the growth of the chill walls a circulating current is set up by the segregate rising within the advancing columnar chill walls, with a corresponding movement downwards along the central axis. Certainly the appearance of the ghost lines within the annular zone strongly suggests such a movement, while the central pyramid, which in one form or another is such a characteristic feature of "killed steel" ingot sections, equally points to the continuous deposition of heavy pure crystallites on the rising fluid floor.

If such a current were set in motion, there would be a tendency for crystallites, forming in the downward current as it cooled near the bottom, to attach themselves to particles of slaggy matter, which would become attached to the floor and there remain. According to this view, the impurer mother liquor would remain fluid for some time longer, so that any rejected segregate would be turned into the rising current then moving upwards towards the head, which might or might not be reached.

The upper annular zone within the lines A A and B B in the diagram does, in fact, indicate the presence of silicate particles



"SILICATE" RESULTS IN 12-TON INGOT

which have escaped entanglement in the lower part of the ingot but which appear to have been trapped together with rising segregate in their journey upwards along the advancing crystalline faces.

It is, however, very difficult to conceive of such a circulatory current, and a more probable explanation is that, just as large globules of rejected segregate forming within the chill wall move upwards by a process of displacement, often leaving behind them intercepted trails to form "ghosts," so also there is centrally a continuous downward movement of purer crystallites, again by displacement. Such a rain of heavy, purer crystallites upon the narrowing and rising solid floor would tend to intercept and carry down some of the larger coalesced particles of slaggy matter, and would also, of course, build a pyramid. Any particles which escaped this sweeping action would, of course, tend to move upwards and come to rest in the pipe cavity, thus leaving the upper central portion of the ingot free of all but the smaller, and therefore more slowly rising globules.

The probability that there is, in fact, such a downward fall of crystallites in the central space was confirmed some years ago in a discussion with Mr. H. Brearley, who based his opinion on indications given by purposely "bled" ingots.

It may be suggested that the relative freedom of the columnar skin from entangled slaggy matter, except such as has reached the surface during casting, and has then been accidentally trapped, is due to the pushing inwards of the larger coalesced globules in the steel by the growing chill crystals. Such globules would, of course, tend to rise with the segregate, with an excellent chance of reaching the pipe cavity. Indeed, in most cases it is probable that the annular zone, where segregate in the form of ghosts is plentiful, is fairly free of entangled slaggy matter, but the case of the ingot shown in the diagram shows quite clearly that this does not always occur.

The relatively high mean silicate content of the bottom-cast 15-cwt. ingot, as compared with the larger ingots, and the lesser degree of variation in the amounts determined at different points, may be explained by supposing that the much more rapid solidification of the steel through to the centre has prevented much coalescence, movement, or escape to the surface, of the globules before they were frozen in.

Much more might be said on this subject, but under the present circumstances the author is content to put forward the evidence, which might be greatly supplemented and confirmed, if necessary, for general information. There are, of course, some very important practical implications, but it is not proposed to enter into these at the present time.

It may, however, be pointed out that there is much more work to be done in this direction before it will be possible to make comparisons of ingots or forgings on the basis of quantitative silicate determinations. The author's results fortunately include a few cases of other makers' ingots, but these were of a similar class of steel, and it is probable that the similar examination of ordinary mild steel ingots, both acid and basic, might lead to some very surprising results, both as regards the nature, amount, and distribution of entangled slaggy matter.

Dr. A. McCance welcomed the paper as the most important on this subject which had been presented for many years. He did not believe that pure manganese sulphide existed in any mass steel, but that point could be settled by analysis. The striking result obtained was the segregation in the lower part of the ingot, and the suggestion that those inclusions were forced down to the bottom could be accepted as probably reflecting what took place. Another idea appeared to be that when the ingot was solidifying there was a layer which was much higher in carbon than the remainder of the ingot. The first crystals deposited from the liquid steel were therefore lower in carbon than the liquid from which they were deposited and that left the liquid richer. Phenomena of that character with the variation in density of the material might give rise to the segregation of non-metallic particles at the bottom of the ingot.

Dr. W. Rosenhain said that the question of the manner in which the silicates were retained in the bottom of the ingot was very interesting, but he did not think the idea of these particles being held down by crystals was very feasible. The question arose as to the origin of the silicates. Dr. Stead showed quite clearly in some of his work that they were due in part to the presence of oxygen in the steel. It must be borne in mind that when the steel fell into the ingot mould, oxidation took place, and there was some oxidation also during the later stages of the pouring process. That explained why the lower portion was richer in silicates than the top. Determining factors were the rate of pouring and the rate of solidification.

Dr. W. H. Hatfield, referring to the results disclosed by the author, mentioned a table given in the report of the Committee which investigated the heterogeneity of steel ingots. That table gave the silicon and sulphur contents of the ingot. Mr. Dickenson's results did not apply to ingots made by all manufacturers. It was shown in the table to which he had referred that the sulphur, instead of increasing as might have been anticipated with a change in position, was much less. It was largely a question of the conditions of production.

Mr. H. Brearley congratulated the author on an excellent piece of work. He had opened up a new line of thought, but had wisely refrained from attempting to draw any definite conclusion from his experiment. He himself gave only a qualified assent to the suggestion that the crystals fell during the solidification of steel cast under certain conditions. It was a point on which it was, of course, difficult to produce direct evidence.

Mr. Dickenson made a brief reply to the discussion, and the meeting was adjourned until the following day.

Owing to the change in the date of the meeting the big hall in the Connaught Rooms was no longer available, and the dinner was held downstairs in the restaurant. It was very well attended. The principal speakers were Sir Hugh Bell, Mr. A. M. Samuel, Sir Frederick Mills, His Excellency Baron Palmstierna (Swedish Minister Plenipotentiary), Sir Sidney Chapman, and the President.

Water-Power Storage by Pumping.

By REGINALD RYVES, Assoc. M. Inst. C.E., M. Cons. E.

Where intermittent or varying sources of power are utilised, storage of power is always a desirable and usually an essential feature of the scheme. In the case of tidal power it may be a lagoon of large capacity or a high-level valley reservoir of proportionately small capacity, a matter depending upon the topography of the place. In the case of wind power, the far greater range of the amount of power received by the plant, the longer periods of large output, and the idle intervals demand a much greater storage, a larger product of quantity and head. A very considerable head may be a feature of schemes in places where there is little water for the initial filling of the reservoir. Stream-power plants can usually be provided with reservoirs of sufficient capacity and fed directly by the streams. Gradually, however, as the most favourable sites are occupied one after another by hydro-electric power plants, it becomes obvious that if the remaining streams are to be fully utilised it will in some cases be necessary, and in other cases an important economy, to provide reservoirs which have to be filled or partly filled by using the plant to pump water into them. Thus an apparent surplus of water may be further or fully utilised. Usually the project will include provision for the collection of all the flow that can be collected and stored without pumping; but cases may occur in which, at very little cost, a dam may be built to form a reservoir of a capacity much greater than the run-off of the valley or glen in which it is situated, and that may compare with a very costly dam to provide full storage of the flow in the main valley. In such a case regulation of the flow by regenerative or storage pumping may be a sound feature of the scheme. A relatively small quantity of water may be pumped to a mountain tarn, or a relatively large quantity into a

reservoir in a tributary valley at a lower elevation. Such pumping may be a daily feature, and carried on during the hours of small demand, or it may be opportunist, as during spates, or seasonal.

THE BELLEVILLE PLANT.

A number of examples of hydro-electric systems of which self-pumping storage is a feature have been described by Mr. M. Martin in recent issues of *La Houille Blanche*, and brief particulars of two of these installations may be of interest. The rivers Arly and Doron, in Savoy, France, meet at Venthon, about 3 kiloms. from their confluence with the Isère. Ranging from Venthon up the valley of the Doron to its confluence with the Dorinet, near Beaufort, and thence up the valley of the Dorinet to Belleville, is a series of hydro-electric power stations, in stages—*étagées*. For daily regulation of flow the lest tunnels of the plants have sufficient storage capacity. Those at Beaufort and on the Doron are altogether 32 kiloms. in length and represent, in daily repeated storage, a reserve of 30 million kilowatt-hours. In order to regulate the annual flow, accumulation or secondary storage reservoirs are provided at high elevations and provide "the greatest possible power per cubic metre of water accumulated." There is, of course, economy of storage space as regards the portion which is pumped to an elevation much above the power station.

The Lac de la Girotte, in the basin of the Girondet, lies at an altitude of 1724 m. water surface, has a capacity of 30 million cubic metres, and a depth of 100 m. The mountain side is pierced at 80 m. below the water surface level, and, from a shaft sunk to this tunnel, a higher level draw-off tunnel has been driven at 39 m. below surface level. The available capacity above the lower outlet is 28 million cubic metres. This volume of water is utilised, first at Belleville and then step by step down to Venthon, a total fall of 1300 m., or 4265ft. It represents some 60 million kilowatt-hours. The rainfall on the small catchment provides some 6 million cubic metres per annum, 14 millions are derived from diversions of mountain streams in adjoining catchments, and 8 millions are pumped from Belleville. The pressure pipes from the lake to that station comprise 360 m. of 1·0 m. diameter, two parallel pipes of 75 cm. for a length of 160 m., diminishing to 64 cm. for 125 m., 60 cm. for 210 m. and increased to 80 cm. for 45 m.

These pipes serve two 5000 horse-power sets at altitude 1213 m. Each group has a centrally placed Pelton wheel, which is coupled on one side to a 3800 kilovolt-ampère alternator, and on the other side to a Sultzer centrifugal pump capable of raising 1600 cubic metres per hour to a height of 500 m. A constant speed of 1000 revolutions per minute is maintained against the increasing head. The two pumps can lift the required 8 million cubic metres in 2500 working hours, the energy absorbed being 16 million kilowatt-hours. The stored water, with the head of 500 m., is equivalent to 8 million kilowatt-hours, giving an efficiency of 50 per cent. The actual cost of the energy used is very small. Further, since the water is available for the whole series of heads, 1100 m. out of the total fall of 1300 m., it represents some 17 million kilowatt-hours, so that the effective efficiency of the pumping is over 100 per cent., and it costs nothing to utilise the 8 million cubic metres which fall on the catchment at too low an elevation to be captured directly by the reservoir.

THE WAEGGITAL PLANT.

The upper end of the valley known as the Wäggital is at an elevation 500 m. above Lake Zurich, and it ends at Siebnen on the eastern shore of that lake. Very favourable topography has led to the building of a dam about 90 m. high, forming a "lake of accumulation" with a capacity of 140 million cubic metres, which serves as a regulator of energy supplied to the Zurich network of the "Société des Forces Motrices du N.E. de La Suisse," and to the principal electrical plants of Switzerland. The total fall of 500 m. between Innerthal and Siebnen is in two stages of 250 m. each, the stations being situated at Siebnen and Rempen. Each station is equipped with plant of 70,000 horse-power in four units. The upper, or Rempen, station has also four pumping sets. The flow of the stream is, during favourable periods, stored in a reservoir of 300,000 cubic metres capacity, and thence pumped into the Innerthal reservoir. The joint capacity of the pumps is 3 cubic metres per second lifted 250 m. Owing to the variation of 8 m. in the water level of the low-level or supply reservoir, the pumping sets are of the vertical axis form, the pumps themselves being under the floor which supports the motors, and adapted for working under water. The pumps, each of 5500 horse-power, are very briefly described as three-stage pumps delivering 750 litres per second at 750 revolutions per minute. The plant was put into service towards the end of last year.

Accumulative pumping as a feature of a hydro-electric power project or system is referred to in the opening paragraphs of the present article as affording, under certain topographical conditions, an increase in total annual output, a means of regulating the flow, or an economy in capital expenditure, beyond what could, in each case, be achieved without it. To Mr. Martin, who is the chief engineer of the "Procédés Sultzer" company of mechanical construction, it presents itself as a feature which is worth considering in general terms, as follows :—

"The relatively small cost of a pumping plant compared with the very large capital expenditure required for works, including dams and pressure pipes such as those at Belleville and Wäggital, makes it impossible to consider the cost of the former. It will be admitted that a mountain hydro-electric plant costs to-day some 3500 to 4000 francs per kilowatt provided, or, say, 20 millions for a 5000-kilowatt plant. The addition of a centrifugal pump to this installation would certainly not increase the cost by more than 500,000 francs. If one considers that, as at Belleville, it may allow of the recovery of some 17 million kilowatt-hours annually, one sees at once that this addition to the plant almost immediately pays for itself."

It seems better, however, to regard regenerative pumping in hydro-electric projects, not as an addition but as a possible element of the system, and as affecting output, regularity, and cost in a series of alternative solutions. The extreme case is exemplified by a project in which the whole of the water would be raised from the sea by a fall to a much lower level, that of the Dead Sea; the hydro-electric scheme for Palestine, described in THE ENGINEER, September 18th, 1825.

In the case of the Motala plant, Sweden, which utilises the storage provided by Lake Wetter and Lake Boren, it is proposed to pump water from the latter to the former during the night hours of small demand for power.

Tests of Turbo-Generator Sets.

For the Foss Islands Road Generating Station of the City of York the Oerlikon Company has supplied two 3500-kilowatt sets and one 6000-kilowatt set, designed for a speed of 3000 revolutions per minute. The acceptance tests of the 6000-kilowatt machine took place on February 25th, 1926, and those of the second 3500-kilowatt set on February 15th, 1923. A comparison of the results is of interest, for great improvement has been obtained both

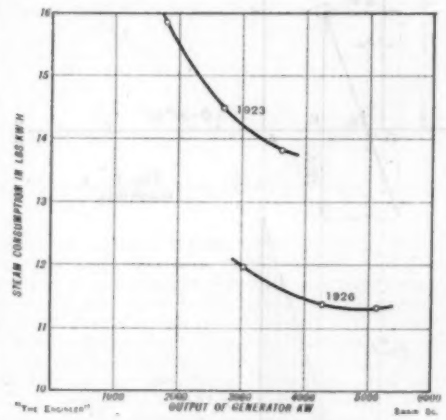


FIG. 1—STEAM CONSUMPTION CURVES

as regards efficiency and steam consumption per kilowatt-hour with the last set.

Both machines were connected to the distribution system during the trials, and the power factor varied between ·96 and ·98 in the case of the 3500-kilowatt set and between ·79 and ·89 with the 6000-kilowatt set.

The 3500-kilowatt unit is designed for dry superheated steam at 160 lb. per square inch (gauge) and a vacuum of

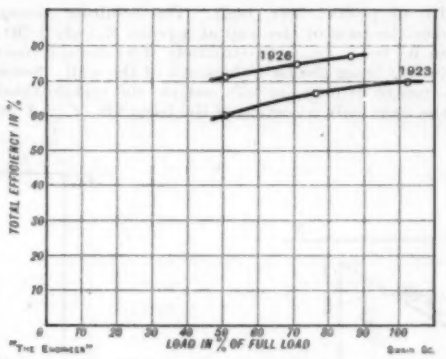


FIG. 2—EFFICIENCY CURVES

28·5in. The normal conditions for the 6000-kilowatt set are 200 lb. per square inch (gauge), 586 deg. Fah., and 28·5in. vacuum. During the tests of the 3500-kilowatt unit the steam conditions were nearer those for which the plant was designed than during the trials on the 6000-kilowatt set. The latter plant is, in fact, working, for the time being, at the lower steam pressure at which the 3500-kilowatt set operates.

The readings obtained are given in Tables I. and II., together with the heat drop available for the turbines and

TABLE I.—*3500-kilowatt Turbo-generator Set Designed for Dry Superheated Steam at 160 lb. Per Square Inch, Vacuum 28·5in.*

1. Output at generator terminals, kilowatts	1769	2688	3595
2. Power factor, cos ϕ	·96	·97	·98
3. Pressure in front of turbine, lb. per square inch (gauge)	151·7	148·8	153·1
4. Temperature in front of turbine, deg. Fah.	401	417·2	437
5. Pressure in front of first diaphragm, lb. per square inch (gauge)	63·9	89·2	127·5
6. Vacuum at outlet of turbine, below, inches	28·84	28·71	28·53
7. Temperature at outlet of turbine, below, deg. Fah.	82·4	83·3	86·9
8. Heat drop from 3 to 6, B.Th.U.	359·1	357·8	356·4
9. Steam consumption per kilowatt-hour, lb.	15·77	14·43	13·79
10. Total efficiency of turbo-generator set at cos ϕ under 2, per cent.	60	66	59·1

the total efficiency of the turbo-generator set derived from it.

In Fig. 1 the steam consumption per kilowatt-hour as a function of the output is plotted, and it will be seen that the steam consumption figures are much lower in the case of the 6000-kilowatt set. This improvement is attributable to the increase of steam temperature and vacuum and also, in no small degree, to the higher total efficiency of the 6000-kilowatt machine. As soon as the new set is fed from the new boilers the conditions will be still more favourable.

Fig. 2 shows the variation of the total efficiency of the sets. Both turbines are regulated by throttling. If the heat drop is calculated for the admission pressure 5 item in Tables I. and II., and the efficiencies, as obtained at tests

TABLE II.—*6000-kilowatt Turbo-generator Set, Designed for 200 lb. Per Square Inch, 586 deg. Fah., and 28·5in. Vacuum.*

1. Output at generator terminals, kilowatts	3025	4260	5140
2. Power factor, cos ϕ	·794	·846	·895
3. Pressure in front of turbine, lb. per square inch (gauge)	157·5	155·4	157·6
4. Temperature in front of turbine, deg. Fah.	521·2	525·7	521·2
5. Pressure in front of first diaphragm, lb. per square inch (gauge)	91·4	126·8	151·7
6. Vacuum at outlet of turbine, below, inches	29·12	29·13	28·94
7. Temperature at outlet of turbine, below, deg. Fah.	74·1	74·1	79·3
8. Heat drop from 3 to 6, B.Th.U.	403·7	403·9	392·9
9. Steam consumption per kilowatt-hour, lb.	11·92	11·35	11·30
10. Total efficiency of turbo-generator set at cos ϕ under 2, per cent.	71	74·4	70·7

for the generator, be taken into account, an efficiency of 81 per cent. and more is attained for the 6000-kilowatt turbine at all loads, in spite of the relatively lower steam temperature and high vacuum, the latter being higher than that on which the calculations were based. For a load of 5140 kilowatts at a power factor = ·895 the efficiency of generator amounts to 95 per cent.

Sixty Years Ago.

A FORTNIGHT ago, under this heading, we referred to Faraday's disclosure to the Royal Society of a new principle for the generation of powerful electric currents, the discovery of Mr. H. Wilde, of Manchester. This development of the magneto-electric machine is of historic importance. It consisted of using the current obtained from an armature revolving between permanent magnets for the purpose of energising the coils of an electro-magnetic machine or dynamo. It is a little difficult nowadays to understand wherein the discovery lay in such a development, for in the light of modern knowledge it scarcely seems to be an invention at all. Yet at the time it marked very real and important progress. We have to remember that in those days the energy obtained from a magneto-electric machine or permanent magnet dynamo was generally considered to be derived from the magnets themselves. The magnets were not regarded as simply a means of producing magnetic flux, but were held to give off electrical energy which was collected by the windings of the revolving armature. A machine without a permanent magnet was therefore beyond the conception of the times. Wilde's discovery expressed in terms of contemporary knowledge consisted in the disclosure that the quantity of electricity to be derived from a permanent magnet could be greatly multiplied by passing it through the coils of an electro-magnet from which the current was finally collected by a revolving armature in the known manner. Even Faraday would appear to have held the view advanced by Wilde that the electro-magnetic part of the equipment was merely an accessory to the permanent magnet machine. In our issue of June 8th, 1866, we described and illustrated an example of a Wilde machine then in course of construction for the Commissioners of Northern Lighthouses. The first part of the equipment consisted of a magneto-electric machine having sixteen permanent horseshoe magnets, each weighing about 3 lb. and capable of sustaining about 20 lb. The armature was of cast iron, about 2½in. in diameter. It was wound in the direction of its length with some 50ft. of insulated copper wire ¼in. in diameter and was rotated at 2500 revolutions per minute. Two steel springs took the current from the commutator and conveyed it to the windings of the electro-magnetic part of the equipment. The magnet coils were wound on two rectangular iron plates 36in. long, 26in. wide, and 1in. thick. These plates, erected vertically, were connected at their top ends by an iron bridge piece. Each magnet was wound with 1650ft. of insulated copper conductor consisting of seven strands of No. 10 wire. The two coils were joined in series. The cast iron armature was 6¾in. in diameter and was wound with 350ft. of ¼in. copper wire. It was driven at 1800 revolutions per minute. Two steel springs took the alternating currents of electricity from two hardened steel collars on the armature spindle. The total weight of the machine was about 1¼ ton. When it was in full action it would, it was stated, require about 3 horse-power to drive it and the lamp supplied by it would then "consume sticks of carbon at least ¾in. square." The time was to come when it was to be found that the electro-magnetic machine was no mere accessory of the magneto-electric machine, and that once the equipment had been set running the permanent magnets could be cut out if part of the current from the electro-magnetic armature were shunted through the electro-magnet coils. Eventually it was discovered that the residual magnetism of the electro-magnets was sufficient to start the generation of electricity without the use of separate permanent magnets.

GOVERNMENT reports show that there are in the Kadur district of Mysore, iron ore deposits totalling some 4,000,000 tons, of which about one-half is suitable for smelting. The iron content ranges from 56 to 62 per cent., and that of phosphorus from 0·05 to 0·09 per cent.

K

Retaining Walls and Geostatic Theories.

By F. W. WOODS, C.I.E., late Chief Engineer, Irrigation Works, P.W.D., Punjab, India.

MODERN methods of calculating the stresses exerted by earth against a retaining wall are dependent largely on theories, which are of uncertain validity, but convenient as a basis for mathematical discussions of the subject. One assumption, generally adopted, is that the earth is in a loose, dry, granular, or pulverulent, condition, in which it cannot remain long at rest—except under compulsion of external forces—with its surface at any angle to the horizon steeper than a certain so-called "angle of repose." But a loose, dry condition is not the ordinary or natural condition of earth, and even when loose earth is laid behind a retaining wall, it is usually rammed or consolidated there in layers, and so enabled to stand at a steeper inclination than that proper to its loose, dry condition.

Sedimentary deposits of clay, loam or shingle, standing erect, in nearly vertical cliffs, 100ft. or more in height, are common natural phenomena; whilst we know that the same soil, under other conditions, may exhibit the semi-liquid characteristics of quagmire, or of quicksand. The engineer, therefore, who may be called upon, in practice, to assign a definite value in any particular case, to the angle of repose of such soil, should bear in mind that the success or failure of his designs will depend more upon the soundness of his judgment as to the present and future conditions of the soil, than upon the mathematical processes that may be based on that judgment.

Another assumption in the accepted theories is that the intensity of pressure in earth supported by a wall is, as in the case of a liquid, proportional at each point to the depth of that point below the surface, though it differs from water pressure in that its direction bears a uniform inclination—say φ'—to the normal to the back of the wall. This assumption seems reasonable in theory, but it is not always confirmed by experimental observation.

Sir Benjamin Baker once drew attention to the case of a trench dug at Baker-street Station, London, in which the soil—clay, gravel, sand, water—at a depth of 20ft., exerted a pressure of only 55 lb. per square foot. In such cases one is confronted with the element of soil cohesion, which is a most important factor of stability.

The factor of soil cohesion should be recognised as having a bearing on theories of soil movement, similar to that which viscosity has on theories of hydraulics, or of hydro-statics; and it ought to be allowed for in the same way; that is, by the application of suitable coefficients of correction, introduced into theoretical formulæ from empirical considerations.

Fig. 1 exhibits the stresses on a vertical rectangular wall, 10ft. thick and 30ft. high, supporting earth with a horizontal top surface, as reckoned by Rankine's method.

Rankine's formula for earth thrust is—

$$P = \frac{w' h^2}{2}\left(\frac{1 - \sin \varphi}{1 + \sin \varphi}\right)$$

If the slope of repose be 1½ to 1—

$$\varphi = 33° 42', \text{ and } \left(\frac{1 - \sin \varphi}{1 + \sin \varphi}\right) = 0{\cdot}286.$$

If the unit weight of the earth $w' = 112$ lb. $= \frac{1}{20}$ ton, we get $P = \frac{900}{40} \times {\cdot}286 = 6{\cdot}44$ tons, against a unit

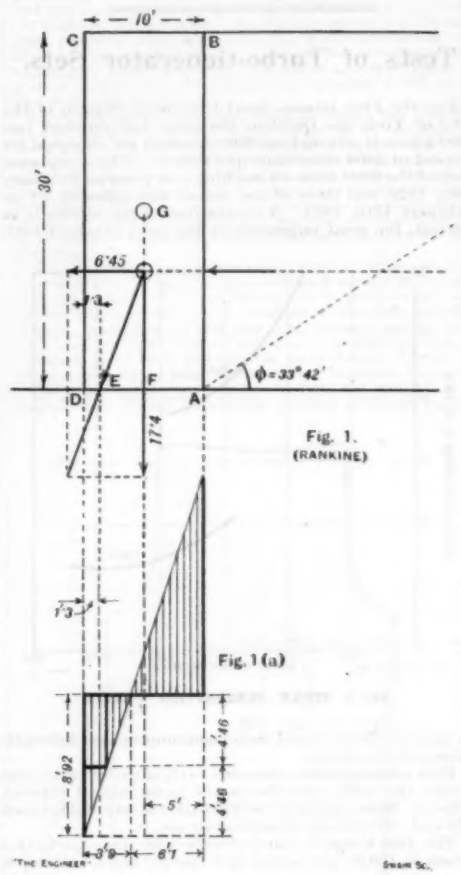


Fig. 1. (RANKINE)

Fig. 1 (a)

width of profile, 30ft. high. The resultant thrust strikes the base of the wall at a point E, only 1·3ft. from its toe; *i.e.*, approximately $(t/8)$ distant from the toe, t being the base thickness of the wall. Since this centre of pressure falls outside the middle third of the base, only a portion of the base, viz., $t' = 1{\cdot}30 \times 3 = 3{\cdot}9$ft., will be in compression. The whole weight normal to base (17·4 tons) will be concentrated on this 3·9ft. length nearest to the toe, giving a mean pressure intensity there of 4·5 tons per square foot. Hence the maximum intensity at the toe will be nearly 9 tons per square foot, and there will be severe tension at the heel of the wall, as shown in the diagram Fig. 1 (*a*).

Now, no ordinary soil can safely bear a pressure intensity of more than about 2 tons per square foot, nor can ordinary lime mortar be relied on to resist tension, and it would be difficult and costly to secure safety in such a case by adequately splaying out width and depth of footings. The conditions indicated by the design, therefore, would be of instability, if true. But they are not true; for Rankine's method of calculation, like most formulæ of hydrostatics, or of hydraulics, needs to be modified in the light of practical considerations. In order to keep the resultant thrust, by Rankine's method, within the middle-third of the base, the vertical rectangular wall would have to be 15ft. thick; whereas by the method of Boussinesq—Fig. 2—that condition is fulfilled with a wall only 10ft. thick. Since experience of construction has shown that the 10ft. thickness is sufficiently stable, this thickness is adopted, although, if the Rankine calculation were sound, it would imply unsafe intensities of pressure at the toe, and of tension at the heel, of the wall. It would be sounder procedure to rectify the exaggeration of the earth thrust, and to design the wall with the centre of pressure lying within the middle-third of the base.

Fig. 3 shows the stability calculations, according to the methods of Boussinesq, of a vertical rectangular wall, 7·5ft. thick and 30ft. high, sustaining earth with a horizontal top. The angle of repose of the earth $\varphi = 33° 42'$, and the plane of rupture bisects the angle $90 - \varphi$, so that $\theta = 28° 9'$. The weight of the prism of earth A B K, contained between the plane of rupture and the wall $= \frac{16{\cdot}05}{2} \times 30 \times 112$ lb. $= 12$ tons. The thrust of this prism strikes the wall at an angle φ' above the horizon, such that $\varphi' = \frac{\varphi + \varphi''}{2}$ where $\varphi'' = \frac{1}{2} \sin \varphi \, (\sin \varphi + \sqrt{8 + \sin^2 \varphi})$. Whence $\varphi' = 31° 5'$. The component of the earth thrust striking the wall at this angle $= 5{\cdot}68$ tons, which, combined with the weight of the wall, gives a final resultant, whose component, normal to the base, is 16 tons, striking the base at a point 1·4ft. distant from the toe. The extent of the base in compression is $1{\cdot}4 \times 3 = 4{\cdot}2$ft. The mean intensity of pressure is $16/4{\cdot}2 = 3{\cdot}80$ tons per square foot, and the maximum intensity of pressure at the toe $= 3{\cdot}80 \times 2 = 7{\cdot}60$ tons per square foot. Such intensities of pressure are more than ordinary soil can endure.

In this case also the design is misleading, for if allowance were made in the calculations for cohesion of soil, the resultant thrust on the base would be found within its middle-third, as shown in Fig. 8.

Fig. 4 illustrates the conditions of stability of a vertical earthen cliff, 30ft. high, with a horizontal top surface. The "angle of repose" is :—$\varphi = 33° 42'$ above the horizontal; and the "plane of rupture" is inclined at $\theta = 28° 9'$ to the vertical. Let us suppose that the bank is ruptured along this plane, and that the displaced earth comes to rest at the angle of repose, along the line M T. The triangle A O M is equal in area to the quadrilateral B O T K. Suppose that, before rupture occurred, a thin masonry wall had

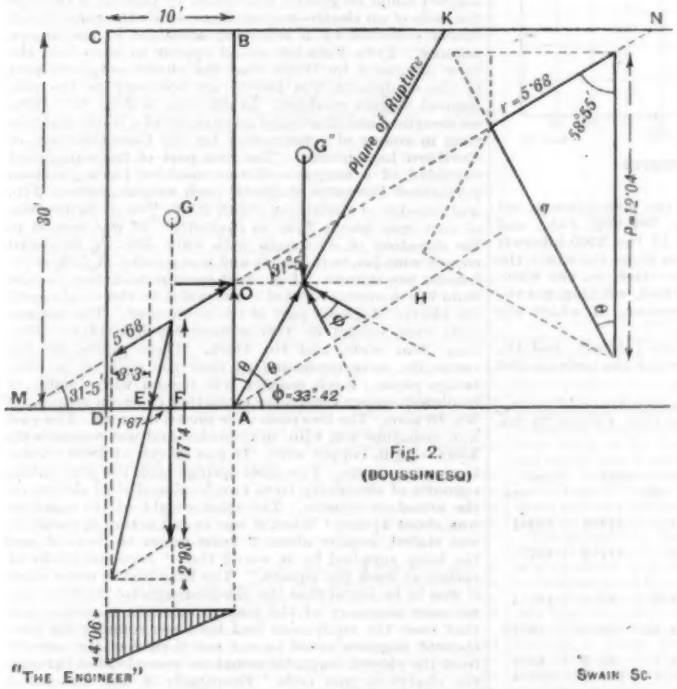


Fig. 2. (BOUSSINESQ)

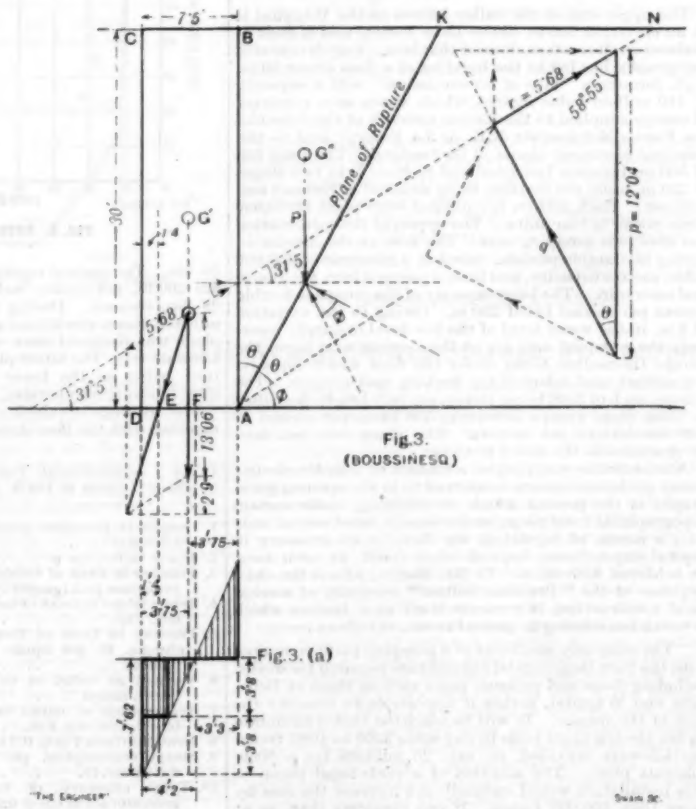
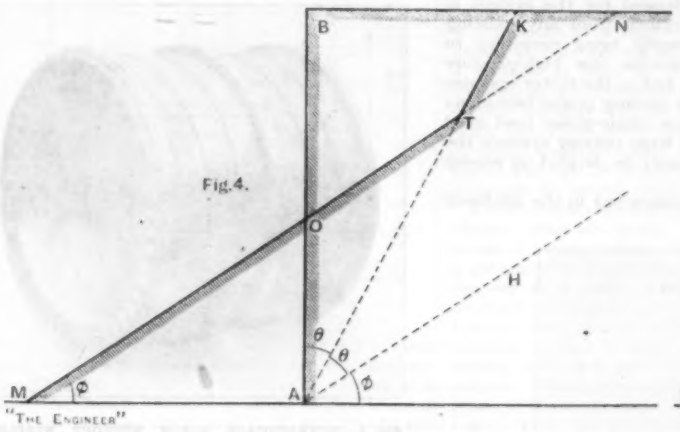


Fig. 3. (BOUSSINESQ)

been built up against the vertical face, A B, of the cliff. It is reasonable to suppose that the earth pressure against such a wall could not have exceeded that due to the triangular prism A O M, that is, to the soil displaced laterally across the vertical plane of the cliff, which bears to the triangular prism A B K, the ratio 0·64. In Boussinesq's calculation the thrust on the wall is deduced from the weight of the prism



A B K as modified by the resistances of the wall and of the plane of rupture. If its magnitude were reduced in the ratio 0·64, and applied to the case of the wall in Fig. 3, the final resultant would strike the base of that wall at a point 2·13ft. from its toe. The mean intensity of pressure on the base would be $\frac{14 \cdot 93}{2 \cdot 13 \times 3}$

= 2·33 tons per square foot; and the maximum pressure at the toe would be 4·66 tons per square foot.

In Fig. 4 the earth cliff is supposed to have slipped along the conventional "plane of rupture," inclined at the angle $\theta = 28° 9'$ to the vertical. In practice, however, earth cliffs do not usually slip along straight inclined planes. In the plains of North India the earth cliffs, or scarps, along the margins of rivers, or bordering the riverain lands, are usually vertical, or nearly so, in their upper levels, and remain so under all the disintegrating influences of rainfall, changes of temperature, &c. Even the sand banks, which emerge above the water level of rivers in the low-water season, are vertical in the upper part of their scarps; and as, from time to time, these scarps are undercut by the current, they flake away along vertical planes of rupture. After rupture the *débris* of a fallen cliff comes to rest at its foot on an inclined plane which represents the plane of repose for loose soil.

Fig. 5 shows what takes place in nature, probably more truly than the conventional "plane of rupture." Here the area of the triangle A O M, with surface inclined at the slope of repose, is equal to that of the parabolic segment B O Q, to which that same slope is tangential. The area of the triangle A O M bears to that of the triangle A B K of the Boussinesq calculation, the ratio 0·567, and it seems reasonable to infer that if a thin wall had been built up against vertical cliff A B, the pressure against it laterally would not have exceeded 57 per cent. of the pressure implied in the Boussinesq reckoning. The weight of the triangular prism A B K is 12·04 tons. If we reduce this to 12·04 × ·567 = 6·83 tons—see Fig 8—the final resultant thrust, correspondingly modified, will strike the base at a point 2·3ft. distant from its toe *i.e.*, practically within the middle-third. The mean intensity of pressure on base will be just over 2 tons per square foot, and the maximum intensity 4·26 tons per square foot. In the force polygon—Fig. 8—the force of soil cohesion is represented by the line *k*. It has the effect of reducing the resultant earth-thrust from $r + r' = 3 \cdot 22 + 2 \cdot 46$ tons, to $r = 3 \cdot 22$ only.

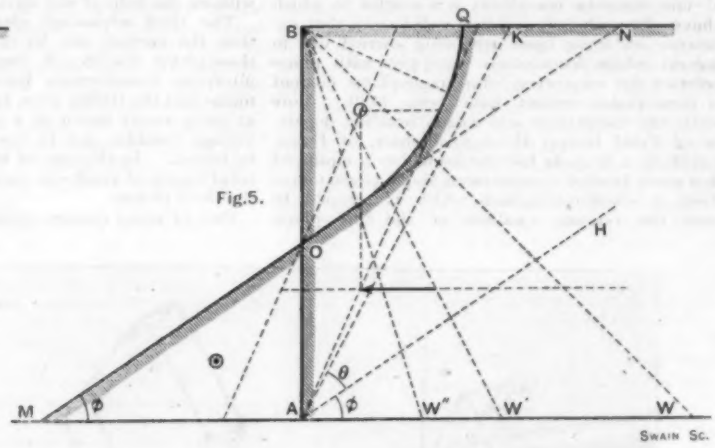
The formula for water pressure against a unit width of a vertical wall, when *w* represents the weight of a cubic foot of water, and *h* the height of water upheld, is $P = \frac{w h^2}{2}$. For the corresponding case of earth, with horizontal surface, with a specific gravity of 1·8 and an angle of repose $\varphi = 33° 42'$, Rankine's formula is—

$$P = \frac{w' h^2}{2}\left(\frac{1 - \sin \varphi}{1 + \sin \varphi}\right) = 1 \cdot 8 \left(\frac{w h^2}{2}\right) \times 0 \cdot 286 = 0 \cdot 515 \left(\frac{w h^2}{2}\right)$$

The author's suggestion is that: $P = 1 \cdot 8\, w \times \left(\frac{\cdot 304\, h^2}{2}\right) \times \left(\frac{1 - \sin \varphi}{1 + \sin \varphi}\right)$ where: $\left(\frac{\cdot 304\, h^2}{2}\right)$ represents the area of the triangle A B W″ = area of A O M—Fig. 7—so that: $P = 0 \cdot 515 \left(\frac{w h^2}{2}\right) \times \cdot 304 = 0 \cdot 156 \left(\frac{w h^2}{2}\right)$

In Fig. 7 the triangle A B W represents the stress area for water-pressure, whilst A B W′ represents Rankine's reckoning of earth-pressure, and A B W″ represents the author's modification of Rankine's A B W′.

Fig. 6 shows that, for a vertical rectangular wall 7·5ft. thick, with horizontal earth surface, and specific gravity of masonry = 2·1, Rankine's construction would show the final resultant thrust striking the base level outside the toe of the wall, which would imply that the wall would be overturned. But we know, from experience, that such a wall, with ordinary conditions of soil below and behind it, would be quite



stable; and this agrees with the conditions of stability shown in Fig. 7, where the final resultant falls only 3in. outside the middle-third of the base. By giving a slight front batter to the wall the final thrust can be brought well within the middle-third of the base.

The author's reckoning—

$$P = 0 \cdot 156 \left(\frac{w h^2}{2}\right) = 9 \cdot 7 \left(\frac{h^2}{2}\right)$$

corresponds to the pressure of a fluid weighing 9·7 lb. per cubic foot. It also agrees with Rankine's reckoning of earth pressure when the angle of repose is taken as $\varphi = 46°$, instead of $\varphi = 33° 42'$; the difference of angle representing difference of cohesion between loose, dry soil, and the same soil when compacted.

Sir Benjamin Baker, as the result of his own extensive experience, and after studying the experimental observations, and the construction practice, of forty years, 1840–1880, stated that:—"Experiment has shown that the lateral thrust of good filling is equivalent to that of a fluid weighing about 10 lb. per cubic foot; and allowing a factor of safety = 2, for vibrations, &c., the wall should be able to sustain at least 20 lb. fluid pressure; which will be the case if its thickness be ¼ of its height."

The method of reckoning earth thrust, suggested by the author, indicates a pressure equivalent to about 10 lb. of fluid pressure, and a factor of safety = 2·67 can be given by keeping the final resultant thrust within the middle-third of the base, instead of allowing it to approach within (*t*/8) of the toe.

It is scientifically sounder to design in this manner than to exaggerate the earth pressure, and, in consequence, to produce a design exhibiting fictitious and unstable conditions, of excessive pressure at the toe, and of excessive tension at the heel of the wall.

It will be noticed that the Rankine method of stress computation gives widely different results in Figs. 1 and 6 respectively, in comparison with those of the Boussinesq method, as shown in Figs. 2 and 3. Yet both methods yield identical results when revised consistently in the manner suggested by the author, and illustrated in Figs. 7 and 8.

Fig.7.
RANKINE (REVISED)

Fig.8.
BOUSSINESQ (REVISED)

A Single-Phase 50-Cycle Electric Locomotive.

THE possibility of working electric railways by means of 50-cycle single-phase current derived from three-phase power stations supplying ordinary industrial and domestic consumers is a matter to which we have often alluded, and it is well known that experiments on these lines are being carried out in Hungary, where locomotives equipped with phase converters for converting the single-phase current into three-phase current have been built. More recently the locomotive and wagon building department of Fried Krupp Aktiengesellschaft, of Essen, has evolved a 50-cycle locomotive which is equipped with a novel type of compensated single-phase motor without a commutator, and which is claimed to possess the running qualities of the three-phase motor. A view of the locomotive and a drawing showing the general arrangement are given in Figs. 1 and 2 respectively.

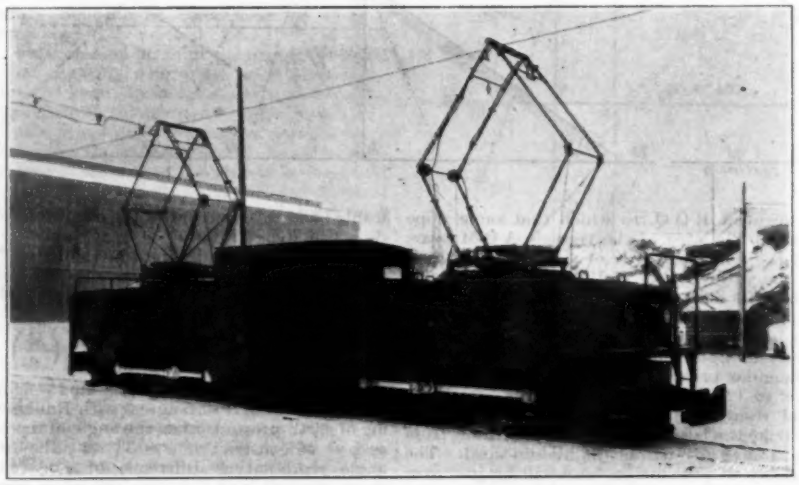


FIG. 1—SINGLE-PHASE, 50-CYCLE ELECTRIC LOCOMOTIVE

The advantage of using a single-phase motor is, of course, that the current can be collected from a single high-pressure overhead wire instead of from two wires, as required with the three-phase motor. In order to endow the motor with the properties of the three-phase machine, a short-circuited winding is made to rotate within the air gap, so as to transform the pulsating stator field into a constant rotating field for the main rotor. The short-circuited winding, which constitutes the intermediate rotor—see Figs. 3 and 4—is embedded in iron, and takes the form of a strong drum held together by rings shrunk on to the periphery, and it runs in roller bearings and revolves idly round the motor shaft. For the purpose of phase compensation, the intermediate rotor is excited by means of direct current, the same winding serving for the excitation, and as a short-circuited winding. The main rotor is provided with a three-phase winding, and resembles in all respects an ordinary three-phase rotor. The new motor possesses all the working properties of a three-phase machine. Its overload capacity for short periods is two and a-half times the normal load, and with a current of two and a half times the normal current the torque is increased by the same amount. Moreover, the motor can be driven in accordance with the cascade system. When run above synchronous speed, as, for instance, on a down gradient, the machine automatically becomes a generator, and returns current to the line. The transition from motive power to electric braking takes place smoothly without any assistance from the driver and without the help of any auxiliary devices.

The chief advantage claimed for the system is that the current can be drawn from any existing three-phase station; it merely being necessary to interpose transformers between the high-pressure mains and the trolley wire, and as the motor operates at unity power factor or a leading power factor, no voltage troubles due to the single-phase load need be feared. In the case of large railway systems the total length of track can easily be divided up among the three phases.

One of these motors, constructed in the electrical works of Garbe-Lahmeyer & Co., of Aix-la-Chapelle, has undergone an exhaustive series of trials on the test bed, and the results are shown in the curves—Fig. 5—where the curve J represents the stator current, i_2 the excitation current, E_2 the voltage at the auxiliary phase, P.S. the output in horse-power, η the efficiency, and S the drop in speed in revolutions per minute. The first vehicle to be equipped with the new motor was a small locomotive designed by Krupp for the removal of spoil in excavation work, and the following are the leading particulars :—

Weight in working order	46 tons
Adhesive weight	46 tons
Number of driving axles	4
Number of motors	2
Speed	6·85 m.p.h.
Continuous tractive effort	9 tons
Total continuous output of motors ..	450 horse-power
Voltage .. 1500–1800 (capable of 3000–3600)	being charged to
Number of cycles	50 per second
Speed of motors .. 750 revolutions per minute at a train speed of 6·85 miles per hour	

The locomotive is designed for a normal speed of 6·85 miles per hour and intermediate speeds between 0 and 6·85 miles per hour can be obtained by means of rotor resistances. The starters are of the liquid type, which ensure smooth starting. Each of the two motors is provided with its own starting resistance, and both are actuated by means of the controller hand wheel. The controller is also equipped with a reversing lever for changing the direction of rotation of the intermediate rotor, and consequently also that of the main rotor. All the parts of the controlling gear are interlocked mechanically or electrically. In addition to the main motors, the electrical equipment of the locomotive includes a motor generator set for supplying the exciting and braking current, a motor for driving the air compressor, two electric foot-warmers, and lighting arrangements.

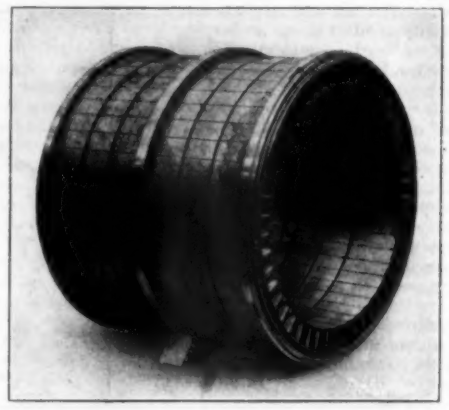


FIG. 3—INTERMEDIATE ROTOR WITHOUT WINDINGS

As shown in the illustration—Fig. 6—the motors are rigidly mounted on top of the spring-supported bogie frames, where they can easily be inspected, and the power is transmitted to the driving wheels through gearing, a jack shaft and coupling rods. The rotor shaft, it will be noted, is arranged lengthwise, and is connected to the gearing by means of a flexible coupling, with the result that the bearings are not subjected to any additional load due to tooth pressure, which is absorbed by the gear box through the medium of roller bearings of large size. The gear wheels, made of high-grade steel and case-hardened, are enclosed in an oil-tight, dustproof case, and are lubricated by means of a pump, which also supplies the roller bearings with oil.

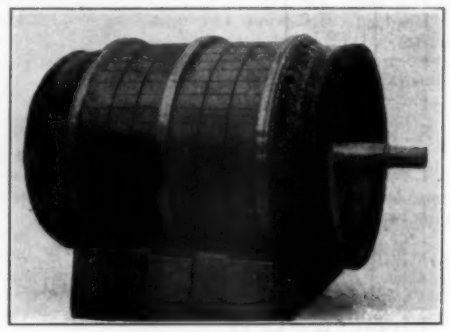


FIG. 4—INTERMEDIATE ROTOR

The locomotive has a single continuous frame, which is mounted on the two bogies; the driver's cab,

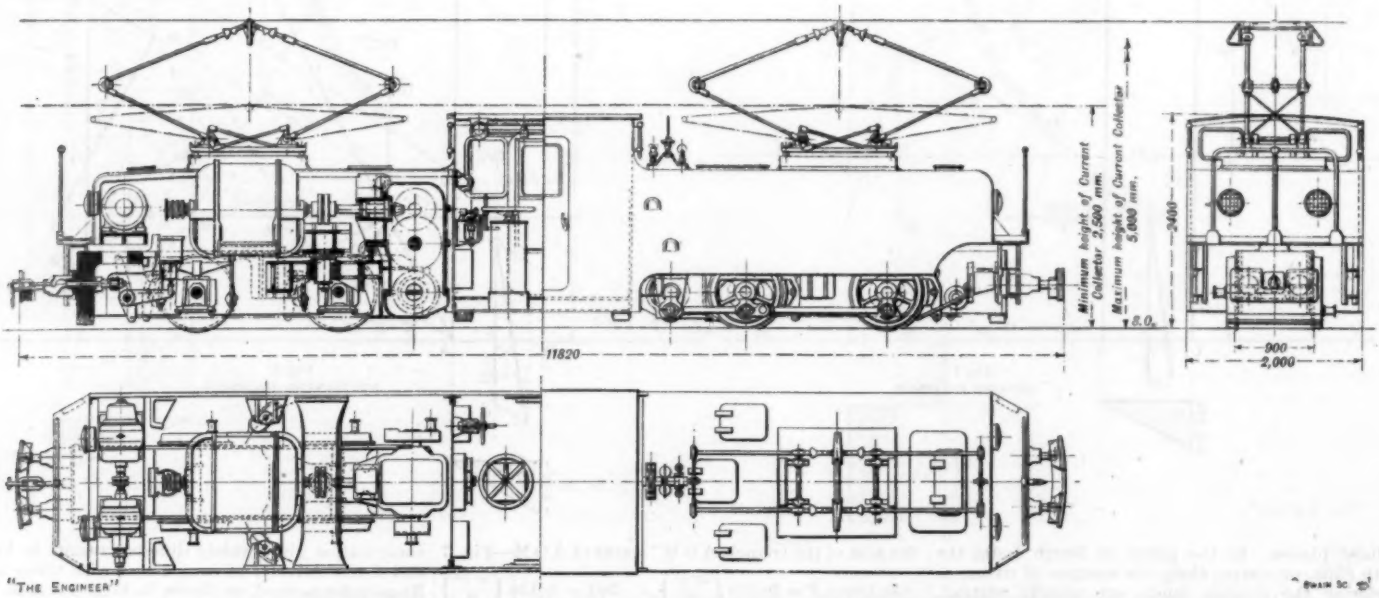


FIG. 2—ELEVATIONS AND PLAN OF SINGLE-PHASE, 50-CYCLE ELECTRIC LOCOMOTIVE

in which all the control apparatus is placed, being situated between the two bogies.

In the publication *Kruppsche Monatshefte*, published monthly by Fried. Krupp, a full description of the new motor used on this locomotive is given by Ludwig Schön, who first calls attention to the well-

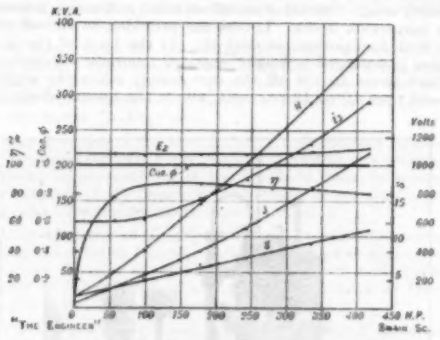
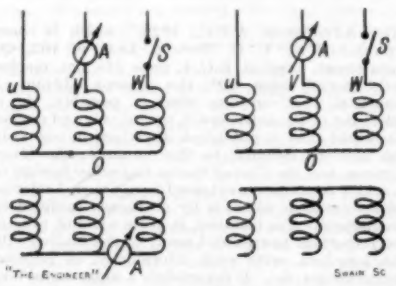


FIG. 5—MOTOR PERFORMANCE CURVES

known fact that if one of the phases of a three-phase induction motor is disconnected whilst the machine is running at no load, it will continue to operate as a single-phase motor. Whilst working in this manner the voltage between the points U, V and W and the neutral point O—Fig. 7—will be practically the same as when the third phase of the motor was connected to the mains and the ratio between the phase voltages and that across the two-phase windings will also be the same as in the case of three-phase operation, viz., 1 : $\sqrt{3}$. If the rotor is stationary and its circuit is opened, as shown in Fig. 8, the reading on the ammeter A is practically the same irrespective of whether the switch S is opened or closed, but the voltage distribution is entirely different. The voltage E (U to V)—the line voltage—is the same with the switch closed or open, but with the switch open the voltage E (U to V) and E (V to W) only amounts to one-half of the voltage E (U to V). The voltages



FIGS. 7 & 8—DIAGRAMS OF STATOR & ROTOR WINDINGS

E (O to U) and E (O to V) both show the same value, viz., 1 (U to V), while E (O to W) is zero.

When the three-phase motor is working as a single-phase machine at reduced output, it still has a very fair efficiency and power factor, the reduction in power arising from the fact that only two-thirds of the stator winding are active. Under single-phase operating conditions the overload capacity is very appreciably reduced. If the voltages between the points U, V, W and O be noted whilst the motor is loaded, it will be observed that as the load increases the conditions become more unsymmetrical. E (U to V) — the line voltage — remains constant, whilst E (V to W) decreases, and when the rotor is brought to a standstill as the result of an overload it is zero. In this case the distribution of voltage is similar to that obtained with the rotor open-circuited.

Provided the rotor circuit of a three-phase motor is closed through a suitable starting resistance, the machine develops a high starting torque. When the machine is connected to a single-phase system, on the other hand, the torque is zero, irrespective of the value of the starting resistance. If when the motor is connected to a single-phase system the rotor be driven at synchronous speed, the motor will generate a voltage as high as the standstill voltage when working as a three-phase machine and the frequency of this voltage will be double the line frequency. With the rotor short-circuited and driven at synchronous speed a current of double the line frequency passes through its windings, while the stator current is double its former value.

From these observations several interesting conclusions may be drawn, viz., in the non-connected phase of a three-phase motor no electromotive force is generated by transformer action. If with the motor running as a single-phase machine, at no load, an electromotive force is set up in the phase O W only a rotary field can be responsible for it, and observations show that a rotary field cannot be produced except when the rotor is short-circuited and is in motion. The electromotive force of the non-connected phase O W serves as a measure of the strength of the rotary field, and it decreases as the load increases and becomes zero at standstill. In that case the alternating field produced by the line voltage is all that remains.

At no load speed the rotating field may be represented by a vector rotating at an even angular velocity, *i.e.*, in a circle. On load being applied it changes into an ellipse and disappears completely at standstill.

Simple mathematical considerations show that an ellipse may be considered to be produced by two vectors rotating in opposite directions, and an elliptical field is produced by two circular rotating fields of different strength rotating in opposite directions. If the two parts of the rotary field become equal, then the ellipse dwindles down to a straight line; that is to say, the resultant field is no longer a rotary one, but is stationary in space, and its strength varies in accordance with a sine law. From the foregoing it will be seen that when the motor is running without load it has a constant rotary field because if this be not so the voltages induced in the three-phase windings displaced by 120 deg. cannot equal each other.

On loading the motor, however, the rotary field ceases to be constant and becomes elliptical, the voltages induced in the three phases being unequal. With the motor at standstill there is no longer a rotary field, as is proved by the fact that no voltage is generated in the disconnected phase. The foregoing views may also be expressed as follows:—When the motor is running idle there is only one rotary field, but when it is loaded there is an additional field rotating in the opposite direction and its strength increases with the load. When the rotor is stationary both these opposing fields are of equal strength, and the currents they induce in the short-circuited rotor produce a right-hand and left-hand torque, which cancel each other.

It follows that, in order to construct a serviceable single-phase motor, care must be taken to reduce to a minimum the part of the line voltage consumed in producing the inverse field, which can only be effectively destroyed by using a short-circuited winding revolving synchronously with the working field. It is clear, therefore, that it should be possible to construct a single-phase motor capable of starting with full load torque, like a three-phase motor, provided that a short-circuited winding revolves synchronously with the working field and is arranged between the stator and the rotor.

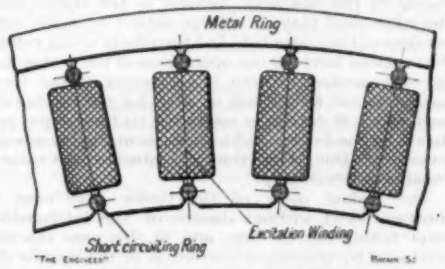


FIG. 10—SECTION OF INTERMEDIATE ROTOR

The new motor that has been devised, is built on quite orthodox lines, except for the wide air gap between the stator and rotor. In this air gap the intermediate rotor—shown in Figs. 3 and 4—revolves. This intermediate rotor is built up of iron bars of H shape cross-section, which are shrunk together with the short-circuiting bars to form a drum. A section of this rotor is given in Fig. 10, whilst Figs. 3 and 4 show the rotor without and with the winding respectively. The excitation winding is accommodated in the grooves between the H section iron bars. As the two air gaps are of the same width as that customary in three-phase motors, the magnetic resistance for the lines of force is not appreciably higher than that in ordinary motors. A view of the motor with the top half of the case removed is shown in Fig. 9.

To prevent the stator flux passing in a tangential direction across the intermediate rotor without acting on the main rotor, the magnetic resistance of the intermediate rotor has been made as high as possible in a peripheral direction. The excitation winding in the grooves of the intermediate rotor is fed with continuous current, and to set the motor in operation the intermediate rotor has to be started by means of one of the well-known methods of producing a cross flux in the air gap. During the starting period the excitation winding of the intermediate rotor and the rotor winding itself must be open-circuited. As the intermediate rotor is not mechanically connected to the

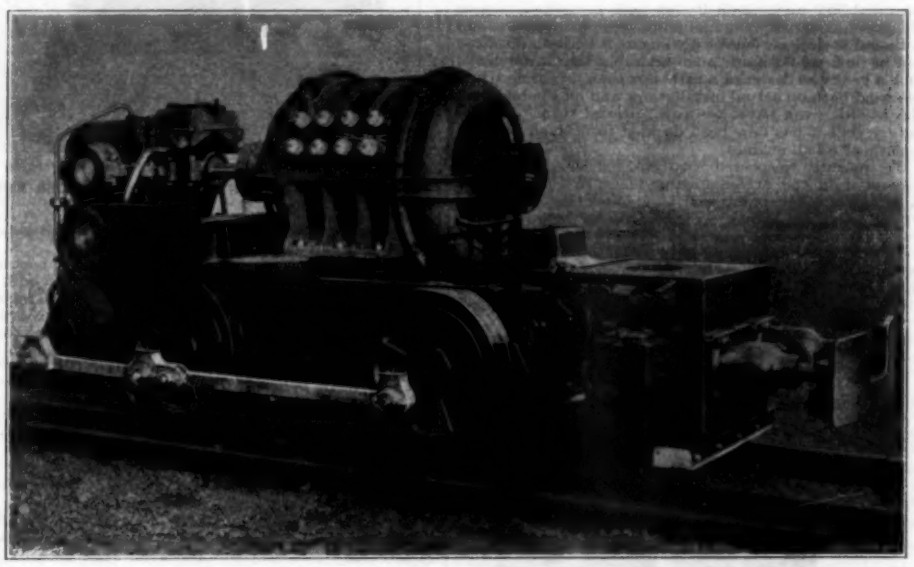


FIG. 6—MOTOR BOGIE

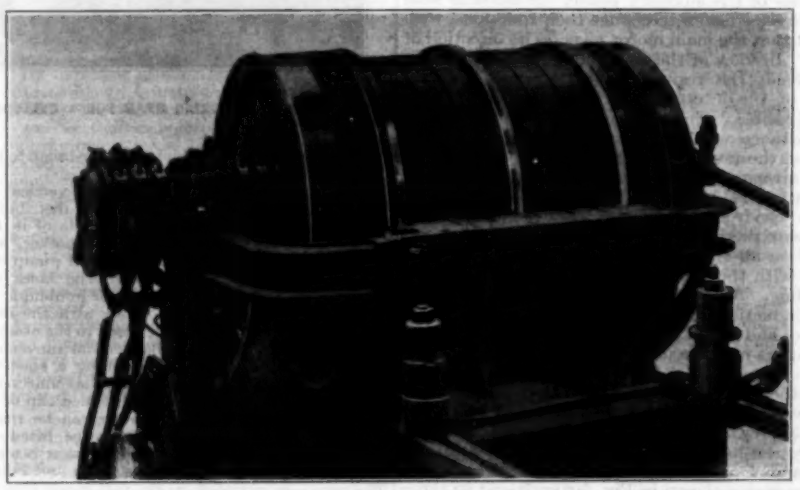


FIG. 9—MOTOR WITH TOP HALF OF CASING REMOVED

main rotor, it only has to overcome its own air and bearing friction, with the result that its speed nearly reaches the synchronous value.

If the excitating current be then switched on, the intermediate rotor, which has small inertia, is easily pulled into synchronism. The direct-current excitation provides the magnetisation, and relieves the system of wattless current, the phase difference being adjusted to any convenient value. The inverse field in the intermediate rotor is destroyed by the short-circuited winding, but there is a weak inverse stray field in the stator. The main field permeates the rotor. If the rotor of the motor is fixed and the machine is used as a single-phase to three-phase transformer, then the three rotor voltages are equal under the loaded conditions. The stator voltages show the unsymmetrical conditions mentioned, especially when the loads are considerable, as the inverse field increases in proportion to the current. As, however, the inverse field is kept away from the main rotor by the intermediate rotor, the former behaves in exactly the same manner as the rotor of a standard three-phase motor.

The motor may be operated at unity or leading power factor at any speed, and during the starting and regulating periods the overload capacity and starting torque may be temporarily increased by over-exciting the intermediate rotor, and by a suitable choice of the magnetic leakage in the stator slots, the rotor field may to a large extent be made independent of the stator field and the effects which voltage fluctuations have on the operations of the motor may be compensated. There is no danger of the intermediate rotor falling out of step, for the mechanical load which it carries is restricted to the torque produced by the inverse field, which is negligible as compared with the torque that the intermediate rotor is capable of developing.

The locked rotor of the motor may even be short-circuited without danger of the intermediate rotor falling out of step, and in this case the field produced by the stator current is in the nature of a stray field, which passes through the intermediate rotor in a tangential direction. Tests are said to have shown that even the most severe load shocks and wide voltage fluctuations in the intermediate rotor show no tendency to make the intermediate rotor fall out of step. When its main rotor has been locked the new motor may be used as a single-phase to three-phase transformer, or *vice versâ*, and in the latter case all the three phases of the three-phase system are equally loaded. The intermediate rotor destroys one of the two revolving fields.

When the main rotor windings are closed through resistances the main rotor revolves in the same

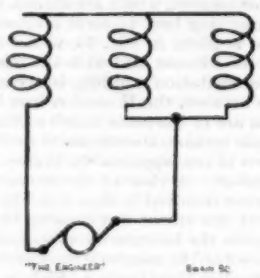


FIG. 11—ROTOR WINDING CONNECTIONS

direction as the intermediate rotor. On the intermediate rotor being reversed by interchanging the connections of the auxiliary phase, the working field and the inverse field interchange their functions, with the result that the main motor reverses its direction of rotation. In view of the complete elimination of the inverse field, the resistance of the short-circuited winding of the intermediate winding should be as low as possible. The intermediate rotor carries a high resistance winding for rapid starting, and for destroying the inverse field, whilst the direct-current winding arranged as part of a three-phase winding—as shown in Fig. 11—serves for phase compensation. It will be seen from this diagram, that the windings for the currents produced by the inverse field are short-circuited on all three phases, and that this does not interfere with the efficiency of the excitation part of the winding. All that is necessary is to ensure that the self-induction of the armature of the exciter is negligible, and when that condition cannot be met accumulators must be used for providing the exciting current.

After the theory of this motor had been worked out it was verified by constructing and testing a 50 horse-power motor on the lines indicated, and subsequently the locomotive shown in the illustrations, Figs. 1 and 2, was built. Apart from slight deviations, the curves shown in Fig. 5 correspond to those relating to a three-phase motor. The power factor was kept at unity all the time, but the efficiency proved to be slightly less than that of a three-phase motor, on account of the additional loss caused by the inverse field.

THE President-elect of the Institute of Transport is Mr. R. H. Selbie, a director and the general manager of the Metropolitan Railway.

A New Fuel Distributing Gear.

THE increasingly successful use of airless fuel injection for multi-cylinder oil engines has caused renewed attention to be paid to the problem of obtaining a uniform distribution of load between the various cylinders of an engine. Such equality of loading implies an equal distribution of fuel to each working cylinder. Failure to ensure such a distribution has frequently led to trouble, which has often been caused by one of the cylinders not carrying its share of the load, and so overloading one or more of the other cylinders.

In the accompanying illustrations we show two examples of a new type of fuel-distributing gear, which has been designed and patented by Ruston-Hornsby, Ltd., of Lincoln, and now forms part of the firm's standard oil engine equipment. In some of the earlier Ruston airless injection oil engines, a useful device was fitted to the ready-use oil tank in order to give the attendant a handy means of daily testing the distribution of the engine load between the various cylinders. It will be recalled that a separate fuel pump was provided for each cylinder of the Ruston engine. On the fuel tank a number of long vertical tubes, corresponding one to each cylinder, fitted with float indicators, were arranged. By means of a suitable arrangement of valves the supply of oil could be cut off from the main tank and be taken momentarily from the float tubes. The simultaneous fall of the float indicators gives an accurate determination of the rate at which oil was being supplied to, and therefore delivered from, the various fuel pumps to the atomiser valves. If any variation in the pump demands was noted it was corrected by adjusting screws on the pump controls until equal oil distribution was given.

The firm, however, has recently felt that notwithstanding the reliability and simplicity of such a method, a gear which would simplify the fuel pump equipment and would at the same time automatically ensure a uniform distribution of fuel, would mark a considerable step in advance. Such a gear was designed a little less than a year ago, and was tried both on actual installations and on the test bed. The results given have, we learn, proved to be so satisfactory that it has now been decided to fit such a distributor gear on all engines.

We recently inspected two applications which are illustrated in the accompanying views, Figs. 1 and 2. In Fig. 1 the fuel pump end of a four-cylinder vertical type Ruston oil engine, designed for an output of 120 brake horse-power, is shown.

Only one fuel pump is now used for all engines other than six-cylinder units, which will be referred to later. The single fuel pump delivers fuel oil under pressure to the

FIG. 1—FUEL DISTRIBUTING GEAR FOR 4-CYLINDER ENGINE

distributor casing from which leads are taken to the various cylinders.

The distributing plunger moves in a vertical steel liner, which is pressed into the gunmetal distributor casing. It is of ground steel and on one side of it is a series of holes, placed vertically one over another, which communicate with the inlet from the fuel pump delivery at various heights of the plunger. The holes are drilled through the diameter of the plunger in oblique directions, so that each connects respectively with the outlet pipes on the distributor casing which lead to the atomiser valves on the cylinder heads. The vertical movement of the distributing plunger is controlled by a steel lifting bar moving on a parallel guide, to which it is connected at the top by a short steel bar. When the domed cap of the distributor casing is removed, this bar can be removed and the distributor plunger may then be lifted out. The reciprocating motion given to the plunger is mechanically controlled by cams, both on its rising and falling stroke. The cams are mounted on the fuel pump cam shaft, and two rollers are provided one on either side of the bell crank lever, which drives the lifting bar. By means of the distributor, oil is directed to the atomisers in the right sequence. No tuning is required once the gear has been set, and only one fuel pump is required. There is a very slight leak of fuel oil past the plunger into the upper cover of the distributor, but this oil serves as a lubricant, and any excess is returned by a duct to the bottom of the plunger passage, whence it is pumped by the reciprocating action of the plunger back to the fuel storage tank or any convenient receptacle.

In the case of the large six-cylinder units, two fuel pumps are employed, but they deliver to a common overflow valve, and from that valve to the distributor casing. Fig. 2 shows a fuel pump and distributor unit for a six-cylinder engine of 750 brake horse-power. The two fuel pumps, the overflow valve and the distributor casing, with its six delivery connections to the atomisers, may be clearly seen. The cams are all enclosed and access is given by inspection doors. Levers are provided to cut off one or both fuel pumps, as desired. At the back of the unit there is arranged a weight-operated emergency governor, which is set to cut off the fuel supply when the engine speed rises 10 to 12 per cent. above the normal designed

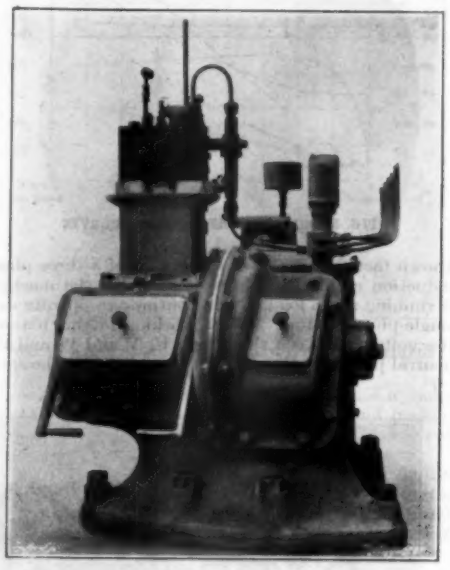


FIG. 2—FUEL DISTRIBUTING GEAR FOR 6-CYLINDER ENGINE

speed of the engine. This attachment can be fitted to all engines if it is required.

During a recent visit to Lincoln we had an opportunity of inspecting the distributing gear in operation on both the engines we have referred to. It was also seen working on a three-cylinder engine for driving a drag line excavator. In all cases the fuel distribution, as indicated by the engine exhaust, was good, whilst the great simplification in the fuel pump equipment was at once apparent.

BOOKS OF REFERENCE

"THE Town and Port of Goole"—or "The Goole Guide Book"—is edited by Mr. J. R. Lloyd Hughes, the editor of the *Goole Times*, and is procurable at the offices of that journal, price 3d. Goole is just about to celebrate its centenary as a seaport—the week June 28th to July 3rd being set aside for the purpose—and the present handbook has been prepared under the auspices of the Goole Urban District Council, the Goole Chamber of Commerce, and the Goole Centenary Publicity Committee, in connection with that event. It embodies such a large amount of information concerning the origin and growth of the town of Goole and of the activities of that port, that it may be fittingly classed among books of reference. It contains first of all a Foreword by Sir John Eaglesome, K.C.M.G., the managing director of the Aire and Calder Navigation, who discusses the question of to what causes the progress of Goole as a port have been due. Then come sections entitled, respectively, "The Story of Goole," "Goole as a Port," "Railway Facilities in Goole," and "Facts about Goole." Then follows a section giving particulars of the locks and of the wet and dry docks of the port, and, finally, there is a chapter describing Goole as a trading and residential town. We have read the whole book through with considerable interest.

"THE Advertisers' A.B.C., 1926," which is compiled and published by T. B. Browne, Ltd., of 163, Queen Victoria-street, London, E.C. 4, price 21s. net, reaches its fortieth annual issue with the present edition. This monumental work contains what is, possibly, the most complete list of the newspapers, periodicals and magazines of the world that is published anywhere in one volume. It has sections devoted to this country, the Oversea Dominions, and the United States and other foreign countries, and it contains an extraordinarily varied selection of useful information which is by no means confined solely to newspapers. For instance, it gives a list of practically all the important towns, and many of the leading villages of the kingdom, with such information as population, stable industries, &c. It is certainly a most useful book to have by one.

WE hear that there is a movement amongst business men in London who are interested in trade with Ireland to form a special section of the London Chamber of Commerce, the whole activity of which is to be devoted to the furtherance of trade with both Northern Ireland and the Irish Free State. The proposed Irish Section would have direct representation on the Council of the Chamber, to which it would submit for confirmation such recommendations as had been arrived at on matters vital to the particular trade or industry concerned, and action would usually be taken in the name of the whole Chamber. All those interested are requested to communicate with the secretary, London Chamber of Commerce, Inc., 97, Cannon-street, E.C. 4.

Railway Matters.

THE Great Northern Railway of America has installed in Montana a windmill-driven turbine and an alternating-current generator, which supplies power for operating 26 miles of colour light signals.

So many ideas for railway working are introduced into this country from America and Germany that it is a satisfaction to know that the "passimeter" system, first used on our own Underground, has been installed at Kreuzberg on the Berlin Underground.

THE directors of the London and North-Eastern Railway have appointed Mr. S. W. Groom, hitherto the assistant running superintendent of the Southern Area, to succeed the late Mr. J. P. Grassick at Cowlairs as running superintendent for the Southern Scottish Area.

THE Ministry of Transport has made an Order authorising the construction of a light railway between the New Romney Station of the Southern Railway and Hythe, which will serve Jesson camp and the village of Dymchurch in the Romney Marshes.

THE American technical papers bring word of the death on May 5th of Mr. Victor Angerer, who was noted for his advocacy and use of manganese steel in railway track. He introduced it on electrically operated railways in 1894 and on steam-worked roads in 1899.

TRAIN destination indicators, which automatically show passengers the destination of the next train and of the two succeeding trains, are now being installed on the platforms at Leicester-square, Tottenham Court-road, Charing Cross, Kennington, Euston, Bank, Moorgate, Waterloo and Morden stations, and will be available for use in about a month's time.

THE death is announced of Herr Rudolf Oeser, who was Minister of Communications in the Stresemann Cabinet of August, 1923, and when the International German Railways Company was formed as part of the Dawes scheme, was made its general director. Though suffering from an exceedingly painful illness, he held that position with great success up to the time of his death, on June 3rd.

AFTER forty years' service the steam tramway between Wolverton and Stony Stratford stopped running on May 19th, as it ceased to pay its expenses. It was much used by the men employed at the Wolverton carriage works, which fact, when its private owners threatened to cease operations, caused the London and North-Western Railway Company to buy it a few years ago and to work it.

THE way in which criminal proceedings in the United States are postponed and dragged along may often be noticed. As a case of that sort arising out of a railway accident, it may be mentioned that on July 30th, 1924, a train was derailed on the Long Island Railway and a passenger killed. The cause was the irregular movement of some points under the train, and not until May 5th was one of the two men concerned sentenced for the offence; the other man has yet to be tried.

THE Irish railway companies have for some time now been in a bad way financially. Proposals for a reduction of wages went before the Irish Wages Board a couple of months ago; some were agreed to, some rejected, and some carried only with the casting vote of the chairman. The men strongly objected to any fall in wages, but further meetings between the companies and the men have led to the findings being accepted, subject to their operation being effected in three instalments. The National Union has undertaken to give no support to any members who take any unauthorised action with regard to the carrying out of the agreement, and the companies reserved the right to cancel the agreement in the event of any stoppage or partial stoppage resulting from the carrying into effect of the agreement.

THERE is an impression among railwaymen, and we admit we were of the same opinion, that the suspension of the guaranteed week was, in a sense, a sequel to the general strike, and aimed at providing occupation for those men who left their work and who, because of the coal stoppage, could not at once be re-employed. The *Railway Review*—the organ of the National Union of Railwaymen—corrects, in its issue of the 4th inst., that impression, and points out that a meeting between the railway general managers and the unions as to a suspension of the guaranteed week had been arranged before the general strike broke out—we presume in anticipation of a possible coal stoppage. We would add that the National Agreement of March, 1919, guarantees all railwaymen a week's pay, but that may be suspended by agreement between the parties.

As anticipated in this column on May 28th, Cannon-street Station was closed last Saturday afternoon, June 5th, for three weeks, to allow for the lines and sidings in the station and station yard to be re-arranged. When the work is completed there will be eight platform roads, instead of nine, but the one dispensed with was only a short one, and its absence will be more than compensated for by the greater length of two others. The numbering of the platform roads is to be reversed, and No. 1 will be on the east side. The junctions and connections have been admirably concentrated, and are to be worked by one power-operated signal-box instead of by two mechanical boxes. That feature will render it possible to dispense with the overhead signal-box at the entrance to the station, which has been in existence since 1865, but has since been extended. It long figured as a fine advertisement for Saxby and Farmer, its builders, and undoubtedly was an excellent example of the safety provided by signalling. An interesting tale may be told of the original locking frame. The signalmen were put to work without any training, and naturally confusion arose, which C. B. Eborall, the then general manager of the South-Eastern, ascribed to the interlocking. He came to the conclusion that so busy a station could not be worked if the points and signals were interlocked, and gave instructions that the locking was to be removed. Needless to say, that was not done. The whole of the track now being laid down was fitted together on some spare ground at New Cross, and even the holes for the points and signalling connections were drilled. There is nothing new in that course, but never before has so large an extent of track been renewed at one time.

Notes and Memoranda.

WRITING to the editor of *Nature*, Mr. J. H. Gardiner says that it is on record that the Egyptians possessed "arms which rust not and glass that might be bended and not broken" some 5000 years ago.

THE new entrance lock for the North Sea Canal, which is being built at Ymuiden, will be by far the largest in the world. Its dimensions are, in metres, 400 by 50, with a depth of 15 m. The next largest lock, on the Panama Canal, is 350 m. by 33 m. by 13·5 m.

A DAM of unusual form is to be built across the Gila River in Arizona. It will be 250ft. high by 600ft. wide, and will comprise three domed arches of about 180ft. span each, supported by two buttresses in the valley bottom. The domes will be open on the downstream side, and the centre one will accommodate a power-house.

PIPE joints for petrol at ordinary atmospheric temperatures can, according to *Power*, be made up tight by first filling between the screw threads of the pipe with a thin paste made of gum shellac dissolved in a 10 per cent. solution of ammonia. The screw threads of both pipe and fittings should be thoroughly cleaned of grease before application of the paste.

THE project for utilising the water power of the Pykara River, near the Mysore border, India, involves the use of a head of 3088ft. at the power-house. A dam, 165ft. high, will provide a storage reservoir of 3826 million cubic feet, and assure a flow of at least 65 cusecs. It is intended to install turbines of 54,000 horse-power, and to transmit the energy to Madras, some 200 miles away.

THE gold yield for the state of New South Wales during the month of March, 1926, amounted to 1238 oz. crude, equal to 1154 oz. fine, valued at £4900. The yield for the first three months of the year amounted to 4201 oz. crude, equal to 3877 oz. fine, valued at £16,468, as compared with 7035 oz. crude, equal to 6409 oz. fine, valued at £27,225 for the corresponding period of last year.

ACCORDING to the report of the Quebec Harbour Commissioners that port had a record year in 1925 in nearly every respect. The total movement of vessels was 957 of 3,897,576 tons, as compared with 668 vessels of 2,460,311 tons in 1924. Total exports amounted to 18,048,362 dollars, as compared with 11,359,104 dollars in 1924, and total imports to 16,338,421 dollars, as against 14,927,881 dollars.

AN outstanding feature of the tenders for the supply of steam-raising plant, which were recently brought before the Electric Lighting Committee of the Sydney City Council, was the marked difference in price between the lowest and the highest tenders. Babcock and Wilcox offered to supply eighteen boilers and accessories for £622,877, whilst the tender of the Australian Shipping Board was £1,035,606.

THE latest Government report on the possibility of utilising Lake Tana, in Abyssinia, for regulating the flow of the Blue Nile, and thus the supply of irrigation water for Egypt and the Sudan, shows that a dam raising the level of the lake by 3 m. would impound 3500 million cubic metres of water. The cost of such works would probably be about 2½ million sterling, and, it is claimed, would have a very beneficial effect in Egypt in droughty seasons.

SOME tests made at Los Angeles, and described in the *Engineering News-Record*, show that practically all concrete piles driven in the harbour there are cracked transversely, but that below the water line these cracks are not detrimental to the reinforcement. It is explained that the cracks become filled with clay, which prevents the circulation of water. Above the mean tide level, however, the cracks resulted in the concrete spalling off and exposing the reinforcement to rusting.

SOME serious leaks, through the fissured limestone, on which the Hales Bar dam across the Tennessee River was founded, were stopped by grouting with asphalt. Holes were drilled through the rock to various depths, ranging up to 134ft., and hot asphalt was pumped down a pipe heated electrically. When the crevice was filled and the asphalt had cooled down, a pressure of 200 lb. per square inch was imposed to consolidate the packing. In all, some 5,000,000 lb. of asphalt was used in the work.

SOME observations made by the Engineer-in-Chief, Board of Trade, on the explosion of a heating tube in a baker's oven attract attention to a matter which is not always fully appreciated. The tube in question failed through overheating, and Mr. Carlton points out that "in the use of coke as fuel the regulation of the draught has an important effect on the temperature of the furnace, apart from the amount of fuel actually on the fire-grate," and, by inference, we gather that the size of the grate has an equally important influence.

IT is reported from Stockholm that at a meeting of shareholders of the Uddeholm Company, it was stated that trials had been made during the past few months at the Hagfors Ironworks of a method of direct electric iron production invented by the chief engineer, M. Flodin. The trials are said to have proved the possibility of producing forgeable iron in this way, but nothing is yet known definitely of the economic aspects of the process. The Uddeholm Company has not yet acquired the method, but has only reserved priority of right to do so if it proves economically profitable.

CANADIAN companies supplying domestic electric current have computed that the average householder consumes 1800 kilowatt-hours per annum, but that amount is, it is said, steadily growing through the adoption of electrically driven and operated domestic labour-saving appliances. The installation of an electric bath water heater increases the consumption by an average of 1800 kilowatt-hours per annum, while an electric refrigerator adds another 650 kilowatt-hours, and washing machines and electric irons another 300 kilowatt-hours. It is expected that, with the more universal use of these appliances, the per capita annual consumption will rise from 1800 to 4500 kilowatt-hours during the next decade. Electric current for domestic purposes in Canada is rapidly replacing coal gas, especially in communities not supplied with natural gas.

Miscellanea.

DAIREN, with an annual trade of over 5½ million tons, is now classed as the second port of China.

A COMPANY with a capital of 5,000,000 dollars has been formed in Canada to develop the power of Grand Falls, New Brunswick.

IT is announced that the work on the port of Matadi, in the Congo, is making normal progress, and that its capacity will be increased by the end of July.

THE new channel, which has been dredged across the bar where the Shat-el-Arab flows into the Persian Gulf, will eliminate the necessity for lightering goods to and from steamers calling there.

ARRANGEMENTS have been completed between the American Steel Foundries, Chicago, United States of America, and Bradford Kendall, Ltd., of Alexandria, Sydney, for the production in Australia of railway specialities in cast steel on American lines.

THE Royal National Lifeboat Institution is organising an "emergency fleet" of boats at Cowes, which will be available for rapid transport by road to supplement the existing emergency fleet stationed at Poplar. The boats will be used to replace any which may be damaged in service.

AN order for three new fruit-carrying steamers of some 4000 tons each has been placed with Workman, Clark and Co., of Belfast, by the United Fruit Company, of New York. The same builders have an order from Furness, Withy and Co. for a 530ft. passenger liner, fitted with oil engines.

TIN is being recovered commercially for the first time in the history of mining in Canada by the Consolidated Mining and Smelting Company of British Columbia. The output, which is from ½ to 2 tons per day in the form of coniterite, is recovered as a table by-product from the Sullivan mine ore. A number of tin ingots were first made in the company's laboratory.

PLANS have been completed, and it is reported that work will soon commence, for the construction of breakwaters and wharves at Cutuco (Salvador) which will turn that port into a satisfactory harbour. La Union is some ten hours' railway journey from the capital. La Libertad is but little over an hour distant by automobile, and Acajutla is about six hours away by train.

ACCORDING to the *Iron and Coal Trades' Review*, a French combine is shortly to be formed for fixing minimum prices for wire and wire products. A similar combine is on the eve of formation in Belgium. Negotiations are in progress between manufacturers in Belgium, Luxemburg and Germany, and it will only require France to join to complete the formation of an international wire combine.

IT is proposed to put up blast-furnaces for smelting a large body of iron ore which has been discovered near Fort William, Ontario. The ore outcrops massively and over large areas, rising in places to heights of 200ft. to 300ft., while diamond drill holes down to 1000ft. have failed to show the bottom of the lenses. The ore is said to contain 66 per cent. of iron, very little phosphorus, and to be free from sulphur and titanium.

CANADA has spent 833,040 dollars on geodetic surveys and reports in the last three years. Of this, about half was spent on field parties and the rest on head office work, compilation and dissemination of data and maps. The expenditure by the Topographical Branch of the Department of the Interior in the last three years totalled 1,405,527 dollars. Of this, about two-thirds was spent on the compilation, printing and dissemination of data and maps and the rest on field parties.

ACCORDING to *British Industries*, a firm near Newcastle recently tendered for repair work in connection with a liner and would have received the contract had it not been for the general strike. In these circumstances the owners decided to send her to Rotterdam, and she was on her way there when the strike collapsed. The firm in question at once got in touch with the owners and prevailed upon them to send a wireless message to the steamer, diverting her from Rotterdam, with the result that they were able to secure the business.

THE discovery of oil-bearing shale, which, according to the Director of Mines, Mr. A. M. Reid, is the richest yet found in the State, has been made to the west of Deloraine, Tasmania. A sample of the shale has been examined by the State Mines Department officials, and found to be exceptionally rich. Mr. Reid has stated that the new field was of very great extent, and from the lie of the land he had no doubt that shale would be found over a wide area. He was coming to the conclusion that the deposits of oil shale in Tasmania were unlimited.

IT is reported from Washington that preliminary permits for hydro-electric development on Passamaquoddy Bay, Me., involving the utilisation of the tides in the Bay of Fundy, have been issued by the Federal Power Commission to Dexter P. Cooper, Inc., New York City. This is the first action taken by the Commission on this proposed development, which is expected by its sponsors to yield 500,000 horse-power. The scheme involves the construction of a number of dams between the islands at the mouth of the bay, so as to make use of the rise and fall of the tide, which amounts to more than 25ft.

THE Secretary for Mines announces that the report of the judges appointed to adjudicate on the electric storage battery locomotive competition for a prize of £1000 offered by Mr. Charles Markham, of Ringwood Hall, Chesterfield, has now been published by the Government Stationery Office. The object of the competition, it will be recalled, was to encourage the production of a safe and efficient type of electrical storage battery locomotive for use underground in coal mines, with a view to obviating the use of pit ponies and increasing coal production. Ten entries were received, five of which were selected by the judges as being suitable for submission to working tests. The winning design was entered by Joseph Booth and Brothers, Ltd., engineers, Union Foundry and Ironworks, Rodley, Leeds.

ELECTRICAL DISTRIBUTION SYSTEM AT HAWARDEN BRIDGE STEEL WORKS

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(*For description see page* 613)

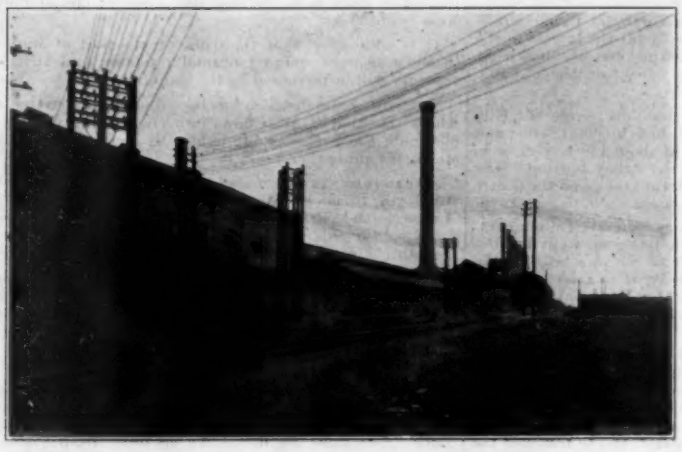

FIG. 1—TERMINAL POLES AT GENERATING STATION

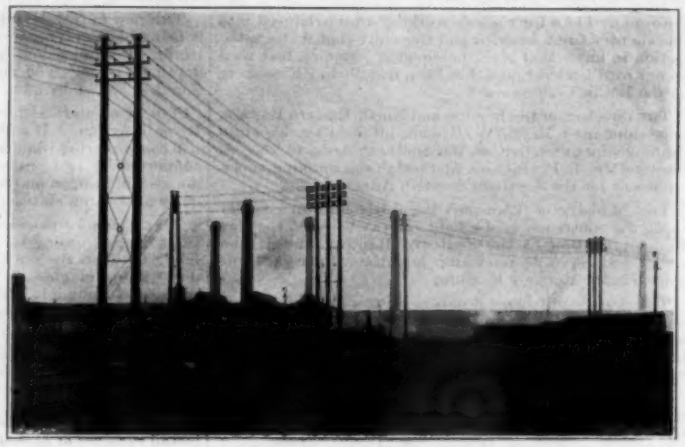

FIG. 2—METHOD OF TAKING LINES ROUND A BEND

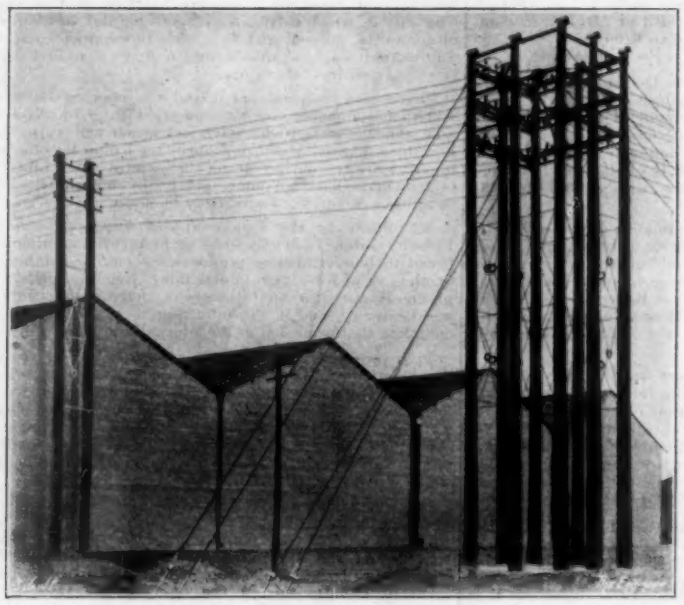

FIG. 3—EIGHT-MEMBER CORNER POLE

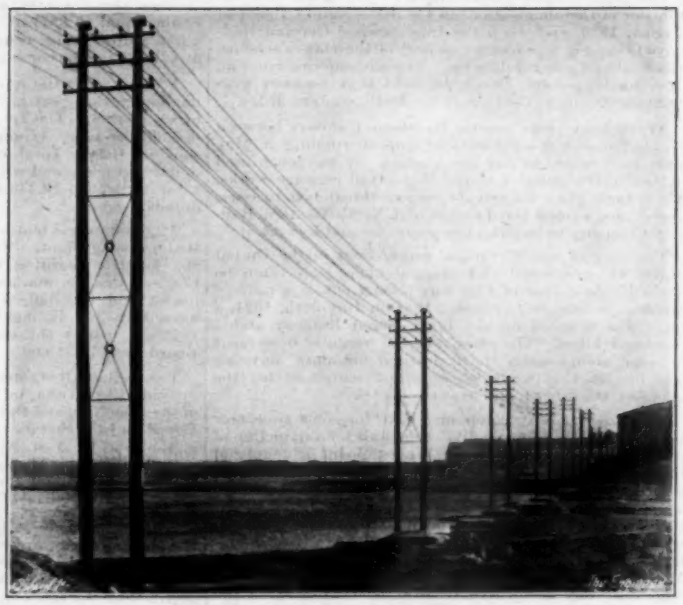

FIG. 4—LINES BETWEEN POWER STATIONS

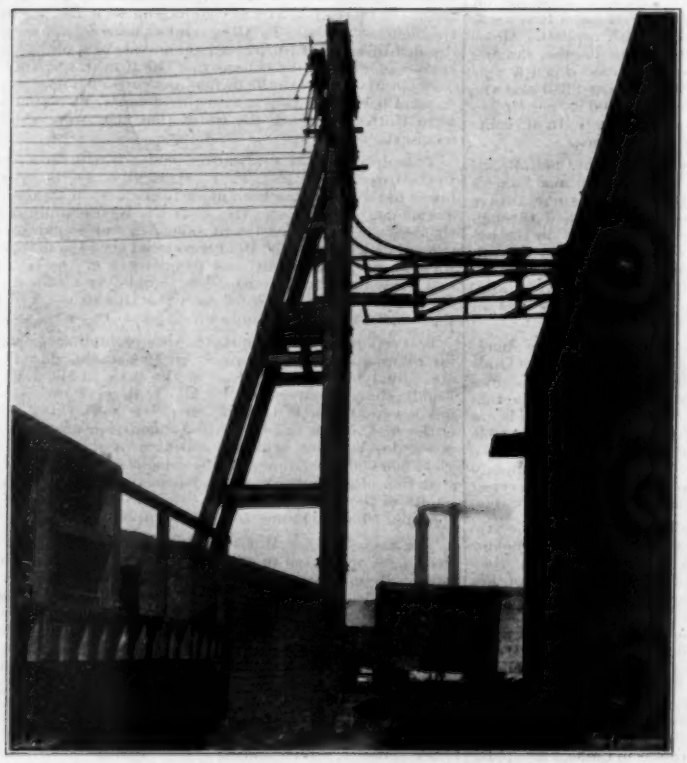

FIG. 5—SPECIAL TERMINAL STRUCTURE

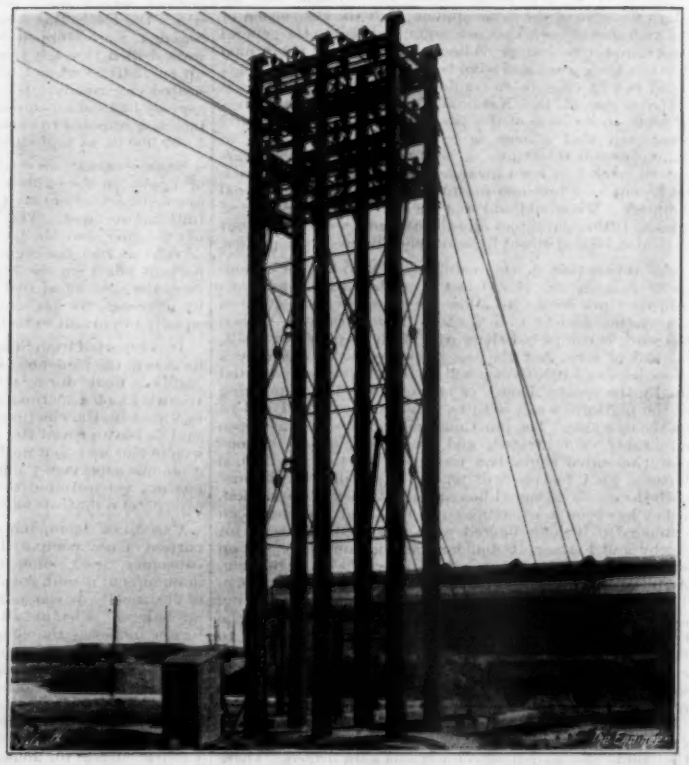

FIG. 6—SIX-MEMBER TERMINAL POLE

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THE ENGINEER.

JUNE 11, 1926.

The Water Capacity of Boilers.

THE demand for boilers of continually greater outputs and higher pressures gives rise to questions which compel the designer at times to reflect upon the fundamentals of his problem. Amongst such questions is that of the water capacity to be provided. Theoretically, a boiler needs no water capacity at all, supposing that it can be fed in exact accordance with the demand for steam. Water has not necessarily to stay in a boiler subject to heat for so many hours before it is ready for consumption. Under suitable conditions, it can be flashed into steam almost instantaneously on entering the boiler. There are certain practical difficulties in making steam in this manner, for unless the rate at which the water is injected, and the rate at which heat is transmitted to it through the boiler walls, are both exactly proportional to the demand for steam at any instant, the steam pressure will fluctuate violently and the system will break down. As a matter of fact, no purely flash boiler has proved satisfactory in practice on account of this difficulty of regulation. A certain amount of water in a liquid form seems necessary to practical operation, and the only question therefore is how much it should be.

So far as heat transmission is concerned, provided that the wetted surface of a boiler is unaltered, there is no reason to suppose that a change in the depth of water covering any surface would make any appreciable difference to the rate of steaming. If water is supplied as fast as it is evaporated, nothing further would seem essential, as any excess of water would merely have to wait its turn. The circulation conditions would no doubt be affected by the greater or less thickness of water in contact with the heating surfaces; but as the only object of circulation is to bring up fresh water, it is only the adequate supply of the latter to every part of the heating surface which need be considered. A boiler designed with the thinnest possible layer of water over its heating surfaces, and no water storage, would, however, be extremely difficult to operate. Any sudden demand for extra steam would have to be met by an instant increase both in the feed supply and in the rate of heat transmission. The former might possibly be provided for, but the latter, owing to the inertia of the fires, it would be almost impossible to obtain with the necessary suddenness. A certain mass of water is required as a sort of fly-wheel to keep things going while the process of accommodation is taking place between feed, fires and output. The question is what is the minimum amount of water necessary for satisfactory operation. In a Lancashire boiler the water contents may be equivalent to five or six hours' steaming at full load. Water-tube boilers for land service a few years ago contained enough water to supply full-load steam for more than three hours, while the modern power station boiler with forced and induced draught could turn the whole of its water into steam in about an hour. These figures, of course, have no significance except in relation to each other, although they certainly indicate the tendency to carry less and less water in proportion to output. A much more interesting figure is the time taken for the water level to disappear from the gauge glasses in case the feed supply is stopped when the boiler is steaming at full load. This does not depend so much on the quantity of water normally carried by the boiler, as on the area of the upper surface of the water. The smaller the drum in proportion to the steaming capacity, the more rapidly will the water level sink. In a modern power station boiler working at normal load, the water will be out of sight in the gauge glasses within five or six minutes of the stoppage of the feed. This time is quite independent of the quantity of water which may be stored in the tubes or mud-drums, and it can only be increased by the provision of more or larger main drums. The drums, however, are the most costly, and structurally the weakest parts of a modern boiler, and with the tendency towards higher pressures there is no likelihood of drum capacity being increased beyond present practice. The trend of events is, indeed, more likely to be the other way. With drums smaller in proportion to output, we shall have even less time before an interruption of the feed becomes dangerous, but even this may be regarded with comparative equanimity. There are many things in a power station which must not stop, besides feed water. The effect of any interruption of the exciting current is, of course, instantaneous, the stoppage of a circulating pump is nearly as bad; the refusal of an air ejector to work does not give many minutes' grace, and disaster is imminent if an oil pump fails in its duty. All these and other potential causes of trouble can be efficiently guarded against and feed-water regulators could no doubt be devised to cope with far more strenuous conditions than exist at present.

A good deal of confusion exists in many people's minds with regard to the exact effect which a large water capacity has on the operation of a boiler. There is an idea that with plenty of water in a boiler there will be some kind of thermal storage effect which will enable the boiler to respond to sudden demands for steam without much drop in pressure. If there was anything much in this idea, boilers of the Lancashire type would be superior to water-tube boilers for variable loads, yet they certainly have no particular superiority for such conditions. It is argued, on the other hand, that a large water capacity makes a boiler sluggish, and unable to respond quickly enough to changes in the load. How much there is in the thermal storage theory can be easily determined by a little arithmetic. A water-tube boiler evaporating 35,000 lb. per hour, may have a water capacity of, say, 30,000 lb. A battery of Lancashire boilers for the same output would have a water capacity of perhaps 195,000 lb. If both plants were steaming steadily at 200 lb. pressure, the water-tube boiler could supply 328 lb. of steam from its own heated water by letting the pressure drop back to 180 lb., while the battery of Lancashire boilers could supply 6·5 times as much for the same pressure drop. Even in the latter case, however, the steam derived from the heated water for a 20 lb. drop in steam pressure is only equal to about 3·6 minutes' normal output of the battery of boilers. An extreme comparison has been taken, and had boilers of even approximately the same type been compared, there would be found no appreciable advantage from any greater water capacity that one might have over the other. As regards the question of sluggishness, one has to distinguish between getting up steam in the first case, and quickness of response to forcing. It is evident that in raising steam from cold water, the less the quantity of water the sooner will the required temperature and pressure be obtained. But when two boilers with different water capacities, but equal heating surface, are both steaming normally, there is no reason why both should not respond equally quickly to the efforts of the fireman. Increase in steam output will depend on nothing else than the transmission of more heat through the boiler heating surface, and this has nothing to do with how much water may be behind those surfaces, provided, of course, that they are drowned. The boiler which would, in fact, have a slight practical advantage would be the one with the larger water capacity, as the feed

might be safely checked for a few minutes while the first demand for steam was being coped with. Furthermore, the normal water level might be restored again without chilling the contents of the boiler to the same extent as would be the case were a less quantity of water in circulation. In this connection, it may be noted that the pressure of high-pressure steam is more sensitive to temperature changes than that of low-pressure steam. In a boiler working at 400 lb. per square inch, the pressure would drop 10 lb. if the temperature of the water were reduced by 2·6 deg. Fah., whereas to produce an equal pressure drop in a 200 lb. boiler the water would have to be chilled to the extent of 4·3 deg. Fah.

Modern practice, in power station work, appears to centre round a normal water content of a boiler equal to about one hour's rated steaming capacity. Over 70 per cent. of this water is usually carried in the tube system, so that any moderate change in drum diameter has no very great effect on the water capacity of the boiler. A change in tube diameter, however, has a considerable effect. Maintaining the same heating surface and drum dimensions, but reducing the tube diameter from 4in. to 3in., would reduce the total water contents of the boiler by about 20 per cent., and would proportionally increase the importance of the water in the drum. Some quite useful work could be done at the present time by an analysis of the proportions of boilers of different modern types, with a view to determining how far water capacity, and therefore cost, might be reduced without introducing too great difficulties in operation. Unfortunately, such work is not "scientific" enough to appeal to our Fuel Research Board, and it may be that we shall have to wait, as has so often been the case, on the American Bureau of Mines, to do for power users in that country what might as well or better have been done over here for the benefit of our own.

Chemists and Power Plant Problems.

THE chemist may be regarded as the engineer of atoms and molecules, and whenever a practical problem turns on the interaction of the ultimate elements of matter, it is to the chemist we usually go for enlightenment. Chemists on their part have not been backward in proclaiming the importance of their own science to engineers, though the latter are perhaps inclined to treat many of their claims with more respect than confidence. Because a chemist can tell us exactly what happens when hot carbon meets oxygen, it does not follow that he is the best man to operate a furnace. No engineer will deny that the complicated reactions which take place in a boiler furnace are purely chemical processes, but so are the more complicated reactions which go to the cooking of a plum pudding, and it is just as logical to demand the services of a chemist to control the latter as the former. The routine operations of a boiler-house, even including the analysis of coal, water and flue gases, can be carried on perfectly well by persons with no greater chemical knowledge than may be possessed by any competent station engineer, and for such duties the presence of the pure chemist is as superfluous as it would be in a kitchen. A real chemist is in fact wasting his time in doing things about a power-house which can be performed quite satisfactorily by someone without his special knowledge and ability. This does not mean to say that the chemist cannot help the power station engineer. His services indeed are most acutely needed, and the need was never greater than at the present time. But in order to be useful the chemist must see the problems from the engineer's point of view. The latter does not look to the chemical profession to make advances in practice. He knows too well that in ninety-nine cases out of a hundred practice runs ahead of theory. It is necessity, not knowledge, which is the mother of invention. Furnaces were built and operated before there was a science of chemistry at all, and steam engines were invented years before thermodynamics. One cannot make much of a theory unless there is first something to theorise about. And, anyhow, the practical engineer wants more than theories. Dealing with hard facts as he does and faced continually with questions which have to be answered by definite actions, the consequences of which may be enormous, he is impatient of the sort of science which pretends to have explained something by giving it a new name. As a rule what the engineer wants the chemist to tell him is what to do in some particular circumstances, rather than what may be going on amongst the molecules. A knowledge of the latter may afford intellectual pleasure, like the theory of the Milky Way or the principles of non-Euclidean geometry, but it, by itself, has no further value. If the molecules are doing some thing we do not like, the all-important thing is to stop them, not merely to state their behaviour.

From the point of view of engineers, chemists are too liable, either to stop short of being really helpful or to go wandering off into investigations of something that nobody but themselves wants to know. The case of lubricating oil may be taken as an example. This is a substance which is an important item in the operation of every power station, and certainly comes within the domain of the chemist. Yet what real help can a chemist give to a man purchasing oil? When the oil turns into sludge in a steam turbine, it does not do the engineer much good to be told that it is a case of polymerization. He would just as soon call it sludge. He looks to the chemist to tell him either how to prevent it or how to guard himself against being sold a similar oil in future, for these are the things he really wants to know. Chemists, again, have argued for years that materials should be bought by analysis, yet they have never yet produced a specification of an oil which could be issued to firms to tender on, with a certainty that every oil fulfilling the specification would be satisfactory. This is a crying need. There must be some difference in the composition of two apparently similar oils to account for the fact that one will lubricate more effectively than another, and chemists should surely be able to find out what this factor is. Men who buy and use oil are infinitely unconcerned with disputes about such theories as that of "boundary lubrication." They do not care two straws whether a lubricating film has a minimum thickness of one molecule or of a million. They want to be able to purchase oil safely to a definite specification, accordance with which can be determined by reasonably simple tests, and "research," to be of practical use, must be intelligently directed to that end. Another subject on which power station engineers would be glad of help from chemists is that of the embrittlement of boiler plates. Practical experience shows that under some conditions the steel of which boilers are constructed will become brittle. Explosions have occurred from this cause, and many an engineer can tell stories of rivet heads flying off one after another when struck with a hammer. The trouble is generally attributed to the presence of free caustic soda in the boiler water. The theory is that the caustic soda attacks iron and liberates hydrogen, which in its active nascent condition permeates the iron and destroys its ductility. In a modern power station, where the whole of the make-up feed water is produced by distillation, there is, so far as is known, no reason to fear embrittlement of boiler plates. But such plants are, and apparently always will be, a small minority. The average boiler plant makes use of water softened by sodium carbonate to get rid of the trouble from hard calcium sulphate scale, or uses a zeolite-treated water for the same purpose. In either case the water in the boiler may become highly alkaline, the carbonate of soda being converted into caustic soda under the conditions of temperature and concentration to which it is subjected. As a practical rule, to prevent embrittlement of the plates it has been suggested that the ratio of sodium sulphate to sodium hydrate should never be less than three to one. Some engineers, in view of the rapid conversion of carbonate to hydrate in high-pressure boilers, think that the ratio should be computed on the assumption that all carbonate of soda should be considered as potentially caustic soda. The idea of establishing a ratio between sulphate and causticity arises from the belief that the presence of sulphate has an inhibiting effect. Those who are not satisfied with this assumption, or who seek a simpler rule, advise that the absolute quantity of carbonate or caustic soda present should be limited to a certain percentage of the weight of water in the boiler. In the Calumet station of the Commonwealth Edison Company, where the zeolite process of treating the make-up feed water is adopted, the excess carbonate of soda resulting from this process is destroyed by the addition of sulphuric acid to the feed water after it leaves the softening apparatus. This converts the sodium carbonate to sodium sulphate, but, of course, results in the production of carbonic acid gas, which is not a desirable constituent of feed water. The West Penn Power Company has avoided the difficulty of undue causticity by substituting tri-sodium phosphate for sodium carbonate, the expense, of course, being considerably greater.

Facts like these show that even large modern stations find it impossible to maintain the water in the boilers of such purity that neither scale nor causticity is developed. The ideal which most station engineers would like to attain would be to ensure that the inevitable losses were made good by pure distilled water, and that the whole of the feed was de-aerated to an oxygen content of less than 0.1 c.c. per litre before entering the economiser. Under such conditions neither scale nor corrosion should occur. Even, however, if a station is laid out on these lines, the engineer has always the possibility of condenser leakage to reckon with. This can soon contaminate the feed sufficiently to cause scale troubles, and if soda treatment is used to mitigate these the danger of causticity looms up again. Scale, corrosion, and embrittlement are all really questions for the chemist, but it is the last which perhaps demands the most study at the moment.

Literature.

The Economics of Carburetting and Manifolding. By R. W. A. BREWER. London: Crosby Lockwood and Son. 12s. 6d. net.

THIS is a book which can be read with advantage by all users of petrol engines, and should result in a substantial saving in fuel, for it is well known that much waste is caused by the indifference of motor vehicle users to the adjustment of carburetters. It is only when there is a scarcity of petrol or rationing of supplies that consumers begin to inquire how economy can be effected. Frequently this can be brought about by sacrificing ease of starting and some degree of flexibility, but the less obvious difficulty and almost equally important source of loss is due to the heavier fractions in the petrol, which are frequently carried into the cylinder, and are unconsumed, causing not only loss of fuel but damage to the wearing parts by dilution of the lubricating oil.

The principal cause of the carburation difficulties is the changed character and composition of motor fuels, a change that has come about so gradually that many motor vehicle owners have not noticed it. Present day petrol, according to Mr. Brewer, has for its chief constituents decane, heavier paraffins and members of the olefin series instead of a large proportion of hexane and heptane. Whereas the earlier petrols evaporated at quite low temperatures, modern petrol requires a high degree of heat to transform the heavier ingredients into gas. The exhaust gas-heated hot spot in the manifold assists the evaporation process, but Mr. Brewer's designs of manifolds embody other features, the chief of which appears to be the provision in the manifold of traps or puddle pockets in which the less volatile fractions of the petrol are caught and stored until they are vaporised and pass over with the gas into the engine cylinder. The book contains numerous illustrations of manifolds designed by the author, as well as others chiefly of American construction.

SHORT NOTICES.

Insulated Electric Cables: Materials and Design. By C. J. Beaver. London: Ernest Benn, Ltd., 8, Bouverie-street, E.C. 4. Price 36s.—While there is no scarcity of literature on insulated cables, the general principles underlying the design and manufacture of cables have not, in the opinion of the author of this volume, been comprehensively dealt with. The author has been connected with the cable-making industry for many years, and the views he expresses are naturally based on practical experience. No other volume so far as we are aware contains so much information of value to cable manufacturers and others who may be interested in the practical side of the business. As the title implies, the volume deals with materials and design, whilst a companion volume will be devoted to manufacture and installation. Much light is thrown on the development of electric cables in the first chapter, where it is shown that the evolution of the insulated cable has resulted in placing at the disposal of the cable maker at the present time four general types of insulation, viz., paper, vulcanised rubber, vulcanised bitumen, and varnished cambric, and that the majority of working conditions under which insulated cables are required to operate may be economically met by those types or a judicious combination of them. There are chapters on conducting materials, insulating materials, protective and preservative materials, whilst that part of the book that is devoted to design contains sections on nomenclature and mechanical principles, conductors, dielectrics, properties and limitations of dielectrics, factors in voltage rating, and sheaths.

BOOKS RECEIVED.

Superheat Engineering Data. London: The Superheater Company, Ltd., 195, Strand, W.C. 2. Price 5s. net.

Surveying. Second edition. By W. N. Thomas. London: Edward Arnold and Co., 41, Maddox-street, W. 1. Price 25s. net.

Universal Directory of Railway Officials, 1926. London: The Directory Publishing Company, Ltd., 33, Tothill-street, S.W. 1. Price 20s. net.

Handbook to British Malaya, 1926. Compiled by Captain R. L. German. London: The Malay States Information Agency, 88, Cannon-street, E.C. 4. Price 2s. 6d. net.

An Electrical Distribution System at a Steel Works.

THE erection of overhead transmission lines or the laying of underground cables in or about an industrial works presents many difficulties which are not met with on ordinary cross-country work. Buildings usually preclude the possibility of making straight runs between points, whilst in many cases it is impossible to lay underground cables at all, on account of the presence of culverts, flues, and other similar obstructions.

An interesting example of work of this nature has recently been brought to our notice by British Insulated Cables, Ltd., the contractors for the extension and reorganisation of the electrical distribution at the Hawarden Bridge Steel Works of John Summers and Sons, Ltd. The works of this firm are situated on low ground, close to the Dee estuary, and cover a large area, the ground between and around the various buildings being water-logged, and consisting largely of clinker, intersected in all directions by obstructions such as those mentioned. The use of underground cables was therefore out of the question, and with the exception of short lengths of cable entering or passing through buildings, it was decided to carry all conductors overhead. Two electrically operated rolling mills with provision for extensions had to be supplied from two existing power stations linked together as shown in Fig. 7. There are four 2000-volt three-phase 50-cycle circuits, with ·25 section copper conductors. Single-core paper-insulated lead-covered cables, laid for the most part solid, serve for connecting the main stations with the overhead lines, whilst the cables running to the motors are of the three-core paper-insulated lead-covered and armoured type. On account of the dirty nature of the atmosphere, 6000-volt insulators have been adopted throughout, for experience has shown that it is well to have a large factor of safety to counteract the effects of coal dust, soot, &c.

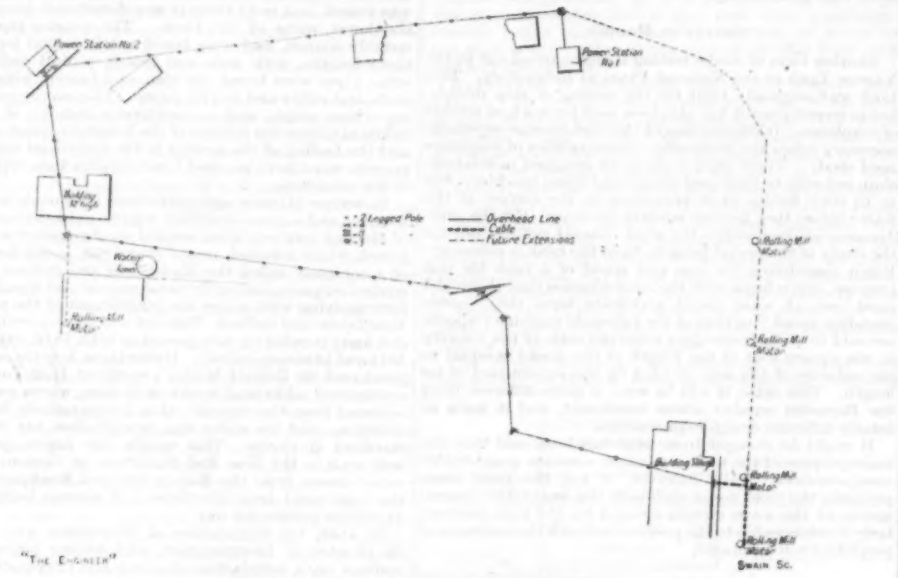


FIG. 7—LAY-OUT OF TRANSMISSION LINES

A special terminal structure erected in a position where it was impossible to employ a stay is shown in Fig. 5 on page 610, from which it will be perceived that the structure is made up of I beams, and that it is strutted. End boxes are provided on the structure for cables which cross a lattice bridge to the main building. In order to avoid vibration and consequent crystallisation of the cable sheathing, the structure is designed on very rigid lines. To have run overhead lines the whole distance would have involved the use of considerably higher poles, in order to clear the roofs, and in one case it would have been necessary to employ a special roof structure, which on account of the light nature of the roof and the stresses which would have been set up by the wind was not considered desirable.

The illustration, Fig. 8, shows a point on the works site where it was found possible to cross a building with a single span by using slightly higher poles than usual, the corner pole being shown more clearly in Fig. 3. This corner pole is composed of eight members, and it carries isolating switches so that any line can be isolated and the feed may be taken from either direction. With the exception of the special terminal structures shown in Fig. 5 creosoted wood poles have been used throughout, because they withstand the atmosphere of a steel works better than steel poles or masts.

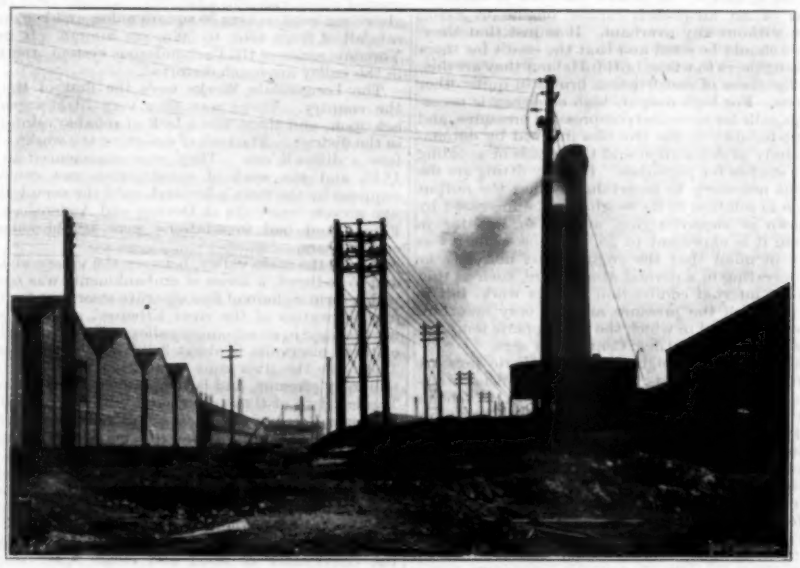


FIG. 8—LINES PASSING OVER A BUILDING

The two six-member terminal poles at one of the generating stations are shown in Fig. 1, where isolating switches are again provided, so that any circuit can be isolated in the event of an insulator or line wire breaking. From this power station the line runs as shown in Fig. 4 to the other power station, where there is a six-member terminal pole, as shown in Fig. 6, this pole having been designed so that the line can eventually be extended from a ring main. The low-lying nature of the ground is indicated in Fig. 4, where it will be noticed that the poles are erected in water. Along practically the whole of this route running sand was found below the surface, and consequently the poles had to be set in concrete.

In connecting power stations together in the manner described, it is well to consider whether the use of reactances is advisable. In the present case reactances have not been employed, but it has been definitely proved that they will be needed when the ring has been completed. Their function will, of course, be to limit the heavy currents at times of short circuits which may occur near the stations and to ensure a more even distribution of current in the ring which will be completed later by means of cables carried on the buildings. The Helsby-Prescot reactances will, it is considered, meet the case admirably, because they can be erected in the open.

The illustrations, Figs. 2 and 8, show clearly the method that has been adopted for taking the line round sharp bends. Double shackle insulators have been used, and the line wire is taken round them, special care being taken to see that the angle poles accurately bisect the angle.

The whole of the distribution scheme was designed and carried out by the engineering staff of British Insulated Cables, Ltd., in collaboration with Mr. K. Younghusband, chief electrical engineer to John Summers and Sons, Ltd.

The Relationship of Physics to Aeronautical Research.*

By H. E. WIMPERIS.

AERONAUTICS is a youthful study—a mere Cinderella of the Sciences, distinguished from her sisters by her tender years, by her guileless and impetuous disregard of the pinch of the financial shoe and by her beauty.

To exhibit the relationship of physics and physicists to this new study is the aim of this lecture.

Aviation is now entering upon a new and intensely interesting phase—one which will call for every scientific resource at our command. The materials of construction are changing; wood is giving place to metal. The engine proves to have most unexpected possibilities ahead of it through the increase of intake pressure; whilst the very lifting structure itself promises to change, for some purposes at least, from linear motion to rotary.

Now in aeronautical work there can be no doubt that science has been very considerably stimulated by problems which have arisen directly from aeronautical engineering. The work of those physicists who have in recent years done such brilliant work on the mathematical theory of fluid motion has been stimulated in no small degree by the results obtained either in the wind channels of our aerodynamic laboratories or in free flight on the full scale.

Aeronautics by its youth escaped the mediævalism of the old-time "practical engineer." It was launched well in the modern scientific path by the formation some seventeen years ago of the Advisory Committee for Aeronautics, which after two phases of readjustment is still with us as the Aeronautical Research Committee. When I first knew it, it was presided over by that kindly and gracious being the late Lord Rayleigh; in those days the field of work was small enough for all matters to be dealt with by the single Committee. Now the scale is so much greater that many sub-committees and panels have to share its responsibilities. The change is so great that I sometimes feel inclined to quote Miss Beale, the famous headmistress—"I was born in the Middle Ages and I have lived through the Renaissance." I quote from memory, but I think I have it right.

The latest phase of that Renaissance is the organisation under the Air Ministry of a separate scientific research department to ensure that scientific investigations shall receive their due and be vigilantly guarded against any competition for money, staff or facilities by the seemingly urgent claims coming from other quarters.

The scientific research staff of the Air Ministry closely resembles the corresponding staff at the National Physical Laboratory in its method of recruiting, its scales of pay and its conditions of work. This staff is about eighty in number, and of this general "pool," some four-fifths work in the laboratories at Farnborough, and the rest at such stations as Martlesham, where the performance of new aeroplanes is studied; Felixstowe, where corresponding work is done for seaplanes; and the Air Ministry Laboratory in the Imperial College of Science, where special problems, mainly physical and chemical, are studied.

THE THEORY AND DESIGN OF AEROFOILS.

The examination of the flow around aerofoils and of the fluid forces brought into play has naturally formed one of the chief items of physical research in the wind channels of the aerodynamic laboratories throughout the world. The simpler measurements usually made on aerofoils are the lift and drag coefficients and the motion of the centre of pressure. These, the ordinary methods of classical hydrodynamics are not capable of predicting from theoretical considerations alone, since the mathematics deal only with the motion of an inviscid fluid—that is, of a fluid in which viscosity plays no part.

In the case of a simple mathematical shape, such as a cylinder, placed at right angles to the flow, the positions of the stream lines, as determined for an inviscid fluid, differ appreciably from those which would arise in a viscous medium, such as air. In the former fluid, moreover, no resultant force acts upon the cylinder, whereas measurements made in an air channel show that considerable forces are brought into play. Indeed, without such forces flying would not be possible.

If, now, to the streaming of the inviscid fluid past the cylinder there be arbitrarily added a "circulation" of the fluid around the cylinder, there at once comes into existence a resultant force at right angles to the stream. This has an immediate analogy with the lift force experienced by an aerofoil, and with the propulsive force pro-

* Abstract of lecture delivered before the Institute of Physics, June 7th, 1926.

duced by the action of the wind on the rotating cylinder of the Flettner rotor ship.

It is seen therefore that by the addition of the idea of a "circulation" around the body a possible explanation is given for the existence of lift forces, and in recent years by the employment of this convention successful efforts have been made actually to predict the lift of certain forms of wing section. Naturally a theory such as this has had to face much criticism, but some years of experience with it have enabled comparisons to be made with data obtained in the laboratory, and such comparisons have shown that it affords a close approximation to what actually happens. The theory itself was built upon the work of many investigators, and among that many I would like specially to refer to the work of Lanchester, Joukowsky and Prandtl. As a result of the work of these and other pioneers therefore we find it useful in aerofoil design to study the effect of imposing upon the motion of an inviscid fluid a "circulation" of unknown origin around the aerofoil of sufficient amount to carry what is known as the "stagnation point" to the trailing edge of the wing. "Circulation" must have a physical existence, since the velocity is greater above the wing than it is below, though this real circulation is a circulation with no slip, whereas the mathematical circulation has slip. Hence, the rather amusing situation arises of adding to the mathematical study of stream lines a conventional motion which could not really arise in an inviscid fluid! So long, however, as the limitations to the theory are borne in mind, no harm can be done, whilst the results of such mathematical work are of the greatest utility as a first approximation as to what is happening.

The great merit of Prandtl's work is that his theory enables the lift of a wing of limited span to be deduced from the known performacne of a wing of the same cross-section, but of unlimited span; in other words, that the results of three-dimensional flow can be deduced from the known two-dimensional. The two-dimensional flow can be studied in two ways—experimentally, by means of a model wing section stretching right across the wind channel; and, mathematically, by the method initiated by Joukowsky, who found a way of predicting these forces by the mathematical step of converting a circle into the desired aerofoil shape by means of a suitable conformal transformation. For a limited number of aerofoil shapes it is therefore possible to deduce theoretically the performance for two-dimensional flow, whilst by the Prandtl theory it is possible to convert these results from two-dimensional to three-dimensional conditions. This work has been put to use by the Air Ministry Scientific Research Staff, and some six aerofoil sections have been designed on this basis with the object of obtaining in the first instance a good thick wing, and, in the second, a good racing wing. This theoretical work has been fully confirmed by subsequent experimental results on such aerofoils, whilst on certain of these wings full-scale work in free flight has been put in hand.

Helicopters.

Many attempts have been made to build aircraft, known as helicopters, fitted with rotating wings, driven by one or more engines. Little success has, however, been met with, in spite of the very considerable expenditure. But in the last year or two real success has been achieved by Señor de la Cierva, with his "autogiro." This machine is not strictly a helicopter, however, since the windmill is not power driven. But I think there is little doubt that it is through the autogiro—or, in English, the gyroplane—that we have the best means of studying the performance of all rotating wing machines. One of the difficulties with a rotating wing is that the wing which is moving in the direction of flight has a higher air speed than the retiring wing, and this leads to much greater lift on one side of the machine than the other. Mechanisms to balance these forces mechanically are most complicated to build, and still more complicated to control. Cierva cut the knot of this difficulty by hinging his blades close up to the vertical shaft. This meant that the advancing blade merely lifted a little above its average angle of inclination, while the retiring blade fell a little below that level; thus, the wings oscillated in a vertical plane during each rotation and presented some analogy to the flapping flight of birds. Centrifugal force prevents the wings from folding up about their hinges.

Owing to wall interference in the wind channel tests that have previously been made on such windmills, or for some other reason, their capacity for slow descent under load was underestimated. This underestimate was first realised as a result of the tests carried out at Farnborough last summer with a Cierva gyroplane, in which the vertical velocity was some 15ft. per second only, about half the speed of fall of a parachute carrying the same load and having a diameter equal to that of the windmill.

Scale Effect in Model Testing.

Full-scale tests on aircraft components usually require a greater space than can be given in a laboratory, and, in consequence, the physical investigations arising therefrom need to be carried out through the medium of models. It is no difficult matter to make an accurate scale model of any form of aircraft, and to provide a wind channel for such dimensions as will make the test reasonably representative. That is relatively simple, but a difficulty soon arises through what is known as "scale effect." The study of scale effect is intricate, and much work has yet to be done. But it has been proved that model tests in the wind channel would represent what happens on the full scale if a certain physical ratio were preserved; this ratio is the product of length by velocity and divided by the kinematic coefficient of viscosity. This ratio is a non-dimensional one, and it is coming to be known as the "Reynolds Number." Model tests in wind channels, as we at present know them, give a value of the Reynolds number of but one-tenth of that appropriate to full scale. This is unfortunate, since it means that within the range of velocities available in the ordinary wind channel, only a very small portion of the correction for the change of the characteristic undermeasurement with the Reynolds number can be studied; hence to deduce full-scale results from wind channel experiments may mean extrapolation in the ratio of something like 10 : 1.

A limit to the air velocity in the channel is imposed by the considerable increase of horse-power for such operation; there is also an obvious limit to the dimensions of channels, and it follows that the only opportunity of obtaining a Reynolds number comparable with that applicable to full-scale conditions is by means of an increase in density of the air, or else of its replacement by some fluid having a higher specific gravity. Much interest has been taken in the pressure channel recently built at Washington which is capable of being operated at an internal pressure of 20 atmospheres, so realising a Reynolds number equal to that of full-scale work, when allowance is made for the fact that a pressure tunnel is best run at about half the air speed of an atmospheric tunnel, so that the amount of the forces acting upon the model may be kept within bounds. It is too early to say whether this channel has entirely fulfilled its constructor's hopes, but from such tests as have been reported it seems that the method of testing rendered possible by its use will prove to be of very great utility.

Seaplane Models.

Another form of model testing is that carried out in the Yarrow Tank at the National Physical Laboratory. This tank was originally built for the testing of ship models, but in recent years it has also been used for work on models of seaplanes. Investigations of this sort become especially necessary when the seaworthy characteristics of seaplanes need study. These craft have to be designed in relationship, not only to their performance as flying machines, but as to their habits when travelling on the surface of the water before they become entirely airborne. For the aerodynamic characteristics the wind channel suffices, but for the study of the period prior to flight the tank is necessary. When considering the size and speed of a tank for this purpose, one is faced with the consideration that the model must run at what naval architects term the "corresponding speed" to that of the full-scale machine; speeds are said to be corresponding when the ratio of the velocity to the square root of the length of the model is equal to the velocity of the ship divided by the square root of its length. This ratio, it will be seen, is quite different from the Reynolds number above mentioned, and it leads to totally different design requirements.

It might be thought from what has been said that the main purpose of the tank is to make accurate quantitative measurements. This, however, is not the case, since probably the chief use of such tests is a qualitative examination of the wave motion created by the hull, particularly in relationship to the position in which the engines and propellers will be placed.

Aero-engine Developments.

The physical problems presented by the aero-engine are for the most part not peculiar to aeronautics, but are part of the general study of the internal combustion engine. The use of this type of prime mover for aircraft does, however, present special problems, owing to the urgent demand for "reliability" on the one hand, and lightness on the other. Moreover, there is always the tenuity of the air at altitude to be reckoned with.

As a matter of fact the aero-engine has enormously improved in recent years, not so much as the result of any scientific study as by sheer hard efficient work on the part of the engineering staffs of the engine builders. As witness to this remarkable success, I would specially mention the performance of the Napier water-cooled engine on the flight to South America, the excellent behaviour of the air-cooled Jaguar engine on Mr. Cobham's flight to South Africa and back, and by no means least the remarkable achievement of an air-cooled Jupiter engine in flying 25,000 miles without any overhaul. It is just that these achievements should be cited and that the credit for them given to the engineers to whose faithful labour they are due.

Need for lightness of construction brings in quite other considerations. For high output, high efficiency is necessary, and this calls for increased compression pressures, and a consequent liability to the troubles induced by detonation. The study of detonation and the means of avoiding it are fitting studies for physicists. Equally fitting are the investigations necessary to ascertain whether the output of the engine in relation to its weight can be increased by what is known as supercharging, and, if so, how far in that direction it is expedient to go. All the while it has to be borne in mind that the engine must not only be capable of operating in a normal atmosphere, such as that in which most internal combustion engines work, but in conditions in which the pressure may be only one-third of that at sea level, and in which the atmospheric temperature may be no less than 50 deg. Cent. below zero.

The sensitivity of the engine to atmospheric pressure has led naturally to attempts to create an artificial atmosphere of increased density in the engine intake. A scheme of this sort was indeed mooted by Sir Dugald Clerk more than twenty years ago, and was called by him "supercompression." It is now known as "supercharging" when the effort is to maintain an intake pressure at all altitudes equal to that at ground level, or "boosting" when the effort is to increase the intake pressure by a constant fraction at all heights. These developments present an infinitude of problems, most of which are now beginning to be seriously tackled—their close relationship to detonation is a complicating phenomenon. There are such great possibilities in this direction that a material decrease in weight per horse-power at altitude may confidently be looked for in the not distant future.

We live in a wonderful age. Just as in the thirteenth century the splendour of life must have seemed most to surround the work of the architect or in the fifteenth century that of the painter, so it appears to me in the present age does it crown the labour and achievement of the physicist.

On page 278 of our issue of March 5th mention was made of certain changes to be effected at Edgware-road on the Metropolitan Railway. Two island platforms are to be provided and four running roads. On Sunday, May 30th, the platform on the down side was brought into use, and the down and up lines slewed over. The existing platforms will now be removed to allow the island platform on the up side to be built.

Manchester Waterworks.*

By W. F. H. CREBER, M. Inst. C.E., F.G.S., Deputy Engineer, Manchester Corporation Waterworks.

Towards the close of the seventeenth century, Manchester had become a comparatively large town, and means of supply were established by Sir Oswald Mosley, the Lord of the Manor, who put down a pumping engine on the river Medlock at Holt Town in Beswick, a short distance outside the town of those days.

Judging from the geological character of the district over which the river ran, the Medlock water at that time must have been soft, clear and good. It was raised by the pumping engine to the higher parts of the town, and conveyed in stone and wooden pipes to the Shudehill pits and the Infirmary Pond—all now swept away—where it was stored, and from there it was distributed by pipes to the lower parts of the town. The wooden pipes were roughly shaped, and were bored out from end to end in short lengths, with male and female conical ends. The stone pipes were bored out also, and formed with spigot ends, and collar and mortar joints. This supply could not have been ample, and a considerable number of the inhabitants, after the failures of the Fountain-street conduit, and the fouling of the springs in the superficial sands and gravels, must have pumped their supplies from wells sunk in the sandstone.

No serious attempt appears to have been made to obtain a better and a more abundant supply until the early part of the last century, when several rival schemes were projected, which resulted, in the year 1809, in the formation of a company called the Manchester and Salford Waterworks Company, and in the same year an Act was obtained for supplying with water the inhabitants of the towns of Manchester and Salford. This Act was subsequently amended and extended by Acts passed in 1813, 1816, 1821, 1823, 1841 and 1846 respectively. Under these Acts the company purchased Sir Oswald Mosley's works at Holt Town, and constructed additional works at Gorton, where water was collected from the streams—then comparatively free from pollution—but the water was, nevertheless, not of a high standard of purity. This supply was augmented by a well sunk in the New Red Sandstone at Gorton, and by water drawn from the Manchester and Stockport Canal, the total yield from the three new sources being about 3½ million gallons per day.

In 1838, the Corporation of Manchester was granted its Charter of Incorporation, and having placed other matters on a satisfactory footing, the Corporation proceeded to consider the water supply, and came to the conclusion that the company's resources were insufficient to meet the growing demand of the town and district. Negotiations with the Waterworks Company were opened by the Council in July, 1846, and in October, the promotion of a Bill in Parliament for obtaining a better supply of water for all public and domestic purposes was authorised.

After an investigation of several possible sources, it was decided to seek Parliamentary powers to appropriate the water draining into the river Etherow, above Tintwistle, in the Longdendale Valley, which is situated partly in Cheshire and partly in Derbyshire. An Act was obtained in 1847 authorising the Corporation to purchase the company's undertaking, and also to acquire the Longdendale gathering ground and to construct reservoirs and works for the conveyance of the water to Manchester. The company's works were purchased and the gathering ground was acquired in the same year—1847. This gathering ground which varies in altitude from about 500ft. to 1900ft. above sea level, covers 30 square miles, and has an average rainfall of from 40in. to 50in. per annum. It lies in the Yoredale series of the Carboniferous system, and the rocks in the valley are much distorted.

The Longendale Works were the first of the kind in the country. There was thus very little experience to act upon, and there was a lack of reliable rainfall records in the district. The task of designing the works was therefore a difficult one. They were commenced in August, 1848, and the work of construction was continued, as required by the town's demand, until the completion of the five service reservoirs at Denton and Audenshaw in 1884. Floods and bad foundations were troublesome in the earlier years.

Across the main valley, between the village of Tintwistle and Woodhead, a series of embankments was constructed which form a chain of five separate reservoirs for impounding the waters of the river Etherow, and two reservoirs were formed in an adjoining valley. The combined capacity of these reservoirs is about 3,400,000,000 gallons. Below Tintwistle the river runs on to Stockport, after receiving tributary streams, and is then known as the river Mersey. The last two of these reservoirs, viz., the Vale House and Bottoms Reservoirs, which are at too low a level for the water to flow by gravitation to Manchester, are used solely for storing water for use as compensation water, which is passed into the river at the foot of the embankment of Bottoms Reservoir at the rate of 13,611,000 gallons per day. The other works in the Valley comprise two sedimentation tanks having an aggregate area of 20,748 square yards, 19½ miles of open and covered watercourses for the conveyance of flood and clean water respectively, syphons laid in the bed of the reservoirs to convey spring water from the Derbyshire side to the clear water course which runs just above the reservoirs along the Cheshire side, and sluices for the discharge of water from one reservoir into another, and for controlling flood water, some of which are operated by electricity and others by turbines. A hydro-electrical plant of 120 horse-power driven by the compensation water, provides current for driving stone-breakers, cranes, stone and wood saws, &c., and also for running an electric loco operating the four mile works railway. From the impounding reservoirs the water is conveyed to a 60,000,000 gallon service reservoir at Godley, about five miles westwards, by an aqueduct which, under the Hollingworth and Mottram Hills, is for a distance of about 3¾ miles mostly in tunnel.

From the Godley Reservoir the water is carried forward in pipes of 30in. and 40in. diameter to a group of seven service reservoirs situated between Denton, Audenshaw and Gorton, and having a total capacity of about

* Abstract of a paper read before the meeting of the Institution of Water Engineers.

700,000,000 gallons, and thence through trunk mains, ranging from 36in. to 10in. in diameter, to the distributing mains throughout the area of supply. Two 30in. mains which supply the North-eastern high level area normally by-pass these reservoirs. As the water leaves the service reservoirs it passes through strainers of fine copper wire gauze.

The total expenditure on the Longdendale Works, including the Audenshaw, Denton, and Gorton Reservoirs, was about £3,088,000.

In the year 1874, or twenty-six years from the time the construction of the Londendale Works was commenced, the attention of the Corporation was drawn to the rapidly advancing consumption of water due to the steady increase of population and of industrial enterprise. The daily consumption was then about 17,000,000 gallons, or within 3,000,000 gallons of the dependable yield of the Longdendale Works, and as there was no ground for expecting any diminution in the rate of increase it seemed highly probable that the demand would overtake the resources of Longdendale in about ten years, not an overlong period in which to find a new source, to obtain Parliamentary Powers for its acquisition, and to construct works for collecting the water and bringing it into the city.

In 1875, the engineer was instructed to report on a fresh source of supply, and the first scheme considered was one for a joint supply of water for Liverpool and Manchester from the two lakes, Thirlmere and Haweswater. This, however, failed to secure the approval of the two authorities, and the Corporation decided to investigate Thirlmere as a possible source for Manchester alone, and having satisfied themselves of its suitability, parliamentary powers for its acquisition were sought in 1878. The application proved unsuccessful, but it was repeated in the following year and resulted in an Act being obtained to acquire the watershed and to construct works for increasing the storage capacity of the lake and for conveying the water to Manchester.

Thirlmere is at the head of the valley of St. John in the County of Cumberland. The gathering ground varies in altitude between 533ft. and 3100ft. above sea level, and has a total area of about 10,800 acres, of which about 7400 acres drain naturally into the Lake, the top water level of which is 587½ O.D. Works are now in progress for the diversion of the drainage of 2400 acres of the remaining area into the lake. These works comprise catchwaters, open watercourses, and a short length of tunnel.

The Corporation own about 12,140 acres, of which about 1960 acres have been afforested, the trees on a considerable area being now fit for conversion into timber. (Tree planting has also been tried at Longdendale, but the smoky atmosphere has caused it to be a failure.)

Thirlmere, when full, is 3 miles 1100 yards in length, covers an area of 793 acres, and holds 8900 million gallons above the invert of the outlet into the aqueduct which conveys the water to Manchester. The storage is equal to a supply of 50 million gallons per day of 156 days, allowing for the compensation water to be discharged, which may amount to 7,000,000 gallons per day. As at Longdendale, the compensation water is used to operate a hydro-electric plant.

The water enters the aqueduct after passing through strainers similar to those at the outlets to the trunk mains from the service reservoirs, and, at the end of the first length of tunnel, which commences at the lake and terminates about a mile north of Grasmere, is turned from the aqueduct into a settling tank, 60ft. wide and 700ft. long.

It is then returned to the aqueduct, which consists of 14½ miles of tunnels, 36¾ miles of covered channels, and four lines of pipes, the total length from the inlet of the aqueduct at the lake to the Audenshaw Reservoirs being 106 miles. It takes nearly three days for the water to cover this distance. Pipes are used only where valleys are crossed and over the coal fields between Horwich and Manchester. They range in size from 36in. to 54in. in diameter and have an average fall of 24in. to the mile. Valves are provided at the head or northern end of each syphon which, on the flow of water exceeding a predetermined speed, close automatically in the event of a pipe bursting. The tunnels and covered channels are about 7ft. high and 7ft. wide, and are capable of conveying about 65 million gallons per day. The sides are vertical and the crown is arched. They are either concrete or brick-faced, with the exception of short unlined lengths of tunnel where cut through rock, and have a uniform fall of 22in. to the mile.

There are two service reservoirs at Prestwich for the reception of the water from Thirlmere, each having a holding capacity of 20,000,000 gallons. At these the first and second pipe lines terminate at present, but these pipes will be connected to the reservoir now in course of construction at Heaton Park, which will have a storage capacity of 500 million gallons. The third pipe line passes across the south side of the city to Audenshaw. At present the fourth line ends at the Booster Station at Lostock.

When the question of laying a fourth pipe at the southern end of the aqueduct was raised, the relative costs with running costs, interest and sinking fund charges, of this pipe and of a pumping station for boosting the pressure in the existing pipes were carefully considered, and it appeared to be more economical to employ pumps, as their number and use could be increased in accordance with increased demand for water, whereas a new main would entail heavy expenditure and not be fully utilised for many years. In the first instalment four pumps have been provided, which can be used on either pipe line No. 1 or No. 2, to increase the pressure and delivery as may be required. The arrangement is shown in the accompanying diagram.

c c = cross connections, with valves.
1, 2, 3, 4 = centrifugal pumps with valves.
5, 6, 7, 8 = centrifugal pumps with valves to be installed.
V = valve closed during employment of pumps.

A.C. current is supplied by the Bolton Corporation and is stepped down and transformed in the Lostock Station.

The capital expenditure on the Thirlmere undertaking to date is about £6,000,000 and the total cost of the entire scheme, when completed, is expected to amount to about £6,500,000.

When Thirlmere was secured for supplementing the water obtainable from the Longdendale gathering-ground it was considered probable that the city would not have occasion to seek another source for a very long period, but in about 1914 or 1915 it became evident from a study of the growth of population in the area dependent on Manchester for a supply of water and of the relation of demand to the resources of Thirlmere and Longdendale, that an additional service would have to be found in time for carrying out the works necessary to obtain an augmentation of supply about the year 1930. It was decided to proceed with the investigation of possible sources from which to secure the additional supply required to meet, for a reasonably extensive period, the growing needs of the city and surrounding districts.

Although Haweswater, which lies in the valley of Mardale in Westmorland, about fifteen miles from Penrith, was from the first regarded as being probably the most suitable source, several other districts were fully investigated before the final decision, to seek parliamentary powers to acquire that gathering ground, was reached. A Bill for this purpose was promoted in 1919 and received the Royal Assent on December 23rd of that year, after a prolonged hearing before parliamentary Committees, at which no less than seventy-six petitions against the Bill were satisfactorily disposed of.

Haweswater is the highest lake in the English Lake district. Its normal surface level is 694ft. above sea level. It is 2¾ miles in length, and varies in width from about 100 yards to half a mile. Its natural water surface has an area of about 350 acres, and its greatest depth is about 105ft. The natural drainage of the lake is 7970 acres in extent, but the scheme as authorised by Parliament provides for the diversion into Haweswater of the drainage of eight additional areas of 15,850 acres aggregate area. The whole area of 23,820 acres consists mostly of crag and moorland and lies geologically in the Ordovician—or Lower Silurian—system, and is now the property of Manchester. The Lake when raised 95ft. in level will be about 4½ miles in length, and rather over half a mile in width, and will have a surface area of about 1000 acres, with an available capacity of 18,400 million gallons.

The 74-mile aqueduct for conveying the water from Haweswater to Heaton Park, Manchester, will comprise,

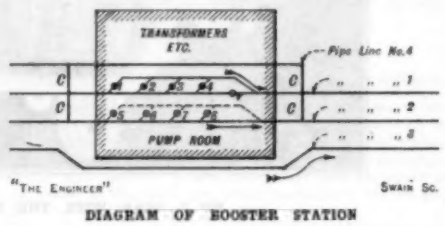


DIAGRAM OF BOOSTER STATION

approximately, 29 miles of tunnel in fourteen lengths, 12½ miles of covered channels in twenty lengths, and seven syphons, aggregating about 32½ miles in length, and a further length of about 9 miles of pipe will convey water to the Audenshaw Reservoirs. It is estimated that the scheme, when completed, will have entailed an expenditure of about £10,000,000.

On the three watersheds the following rainfall readings have been recorded at certain stations :—

	Longdendale.	Thirlmere.	Haweswater.
	in.	in.	in.
Largest fall in a month	13·9, Sept., 1918	35·0, Sept., 1903	21·30, Oct., 1923
Largest fall in a day	3·19, Aug. 7th, 1922	3·90, Feb. 10th, 1922	3·91, Jan. 1st, 1925
Minimum fall in a month	0·04, June, 1925	0·20, June, 1925	0·07, June, 1925

The Longdendale rainfall records extend over seventy years. The gauge for compensation water, a Venturi gauge at Godley, and a Lea weir recorder at Bottoms Reservoir, taken together, enable a fairly accurate record of the Longdendale gathering ground run-off to be kept. At Thirlmere the compensation water gauge, a Lea weir recorder on the lake overflow, and a rectangular Venturi gauge—capable of measuring 70 million gallons per day—in the aqueduct at the end of the first tunnel, give the total quantity of water flowing off the gathering ground. The rain gauges give averages—on forty-nine years—varying from 75in. to 105in. A monthly fall of upwards of 20in. has been recorded several times on one gauge—elevation 2100 O.D. In the Haweswater and adjoining valleys a number of recording stream gauges are in operation and remarkable differences of run-off are shown. There are twenty-five rain gauges spread over the whole area and they illustrate very clearly the difficulty of obtaining a correct average. Some give, in accordance with regional topography, results such as might be anticipated, but neither elevation nor relation to the watershed can be given as an explanation why some records are low and others are high. The curious curves of the hyetal rainfall map, based on the five years' average fall, show the difficulties of the problem, whilst the mean of all the gauges gives an average which is possibly far from being correct. The average rainfall is considerably lower than that of the Thirlmere area, and the highest average of any one gauge—the elevation of which is 1477 O.D.—is 99 in.

The average daily consumption of water in the area covered by the Manchester supply, which is now about 53¾ million gallons, has been growing during the past decade or longer at an average rate of rather over one million gallons per annum. The future growth may be at an accelerated rate, but if it continues only at the rate of about one million gallons per annum, the demand will have overtaken the resources of Longdendale and Thirlmere in about ten years, by which time such portions of the Haweswater Works and Aqueduct as are necessary for bringing the first instalment of water to Manchester will have to be completed. Manchester is at present responsible for the supply of water in bulk and in detail over an area of about 169 square miles, containing a population of about 1,550,000, and a considerable increase of bulk supplies is expected on completion of the first Haweswater instalment. The number of dwelling houses connected to the supply is 264,000, and the average daily consumption per head of the population supplied is about 36¼ gallons, of which 22¼ gallons are used for domestic and public purposes, and the remaining 14 gallons for manufacturing and trade purposes. The water is conveyed from the service reservoirs to consumers in pipes having an aggregate length of 1220 miles. There are 35,000 valves and hydrants on the trunk and distributing mains for regulating and controlling the supply, and they are operated and examined on an average twice a month, about forty men being regularly employed on the work. The number of trade meters in use is 9100 on the low-pressure supply and 720—Kent's—on the high-pressure system. About 1000 of the former are Kennedy meters, which have been at work for many years, a large number of "Manchester" meters are in use, and there are smaller numbers of Siemens', Kent's, Helix, &c., meters.

The number of men employed on waste detection work is sixteen, and the loss of water over the entire system is under 4 per cent. of the whole supply, which compares favourably with most of the other large water undertakings in the country, remembering that colliery workings extend under the greater part of the area of supply north of Chorlton.

While the Manchester area of supply is not divided strictly into zones, the districts served from the various reservoirs are to some extent marked out by their elevations. The old part of the City of Salford lies low and is supplied, in bulk, from Denton Reservoirs. Gorton Reservoirs supply the lowest part of Manchester, and Audenshaw and Denton Reservoirs supply the remainder of the central Manchester area and most of the southerly areas, but a part of the Altrincham district is served from a trunk main fed off one of the Thirlmere Aqueduct mains, which also supplies mains in the Trafford Park area. The north-western area is worked from Prestwich Reservoirs and the north-eastern area is supplied from Godley, with the help of automatic boosters in three sub-areas.

The 30in. mains from Godley Reservoir are used principally for the supply of the north-eastern part of the area of supply, but branches from them are also laid throughout the heart of the city for fire services, and about 250 sprinkler installations are supplied from them in addition to a large number of private hydrants, as well as other sprinkler installations on metered supplies. In the streets, triple hydrants are attached to the 18in. pipes served from the Godley mains.

The pressure added by the booster pumps of course varies considerably, but is usually about 40 lb., and the cost is about 1d. per 1000 gallons. When the Haweswater water becomes available the three existing small sets will be no longer required and will be retained merely for stand-by purposes. A new set is being installed for stand-by use on an 18in. pipe serving the higher levels of the North Cheshire district.

Besides the low-pressure system, the Corporation Waterworks maintain an hydraulic power supply, provided from three pumping stations from which the water is sent out at 1100 lb. per square inch pressure, day and night. This is used for a variety of machines, but mostly for presses and lifts, contained in 600 premises, the total number of machines in use being over 3000. A borehole has been sunk at each station and about 75 per cent. of the water used for condensing or sent into the high-pressure mains is raised from the three holes, the balance of water required being obtained from the low-pressure mains.

The total installed motor and engine horse-power of the three stations is 5800 ; there are two accumulators at each station, and trunk mains give intercommunication between the three stations.

Parts of the Thirlmere Aqueduct as well as a considerable part of the Manchester area of supply are in the coal mining area, and subsidences have caused much trouble. A large part of the area covered by the reservoirs at Audenshaw showed serious signs of subsidence, and expensive repair work was found necessary. A prolonged legal case against the owners of the colliery working under the reservoirs was settled by the company agreeing to cease operations within the area affecting the reservoirs, the Corporation having to pay heavy compensation for coal not won.

On the Thirlmere Aqueduct some pipes have been fractured, and it has been found that the pipes were under severe compression, and pieces of iron have been thrown out of the trench, on opening up the ground. Where the Thirlmere Aqueduct passes through a hill north-west of Bolton, near Lostock, it runs on the hydraulic gradient in three lines of pipes—two of steel and one cast iron—laid in a pair of tunnels. Mining operations underneath have resulted in considerable damage to the brick roofs and concrete floors. The unwon coal has been purchased below and for some distance around the tunnels, and as they apparently have reached a state of rest, repair work is in progress, one tunnel having now been made sound by new concrete and grouting.

Diesel Engine Users Association.

AT the May meeting of the Diesel Engine Users Association, which was held on May 28th, the President, Mr. E. W. Johnston, gave an account of the considerable amount of work which had been done by the Committee in connection with the preparation of "Specifications for Lubricating Oils for use on Heavy Oil Engines," which specifications the Association subsequently adopted at that meeting.

The Association had, he said, for several years issued an annual report on the working costs of heavy oil engines. These reports, which dealt with some forty representative installations, had a considerable circulation, and were regarded as affording standard data on the subject. In preparing these annual reports, the Committee could not help noting the wide variation in the consumption of lubricating oil per unit generated. Even allowing for differences in load factors, the consumptions in some instances were about five or six times as much as others. Such wide variations were all the more striking when compared with the small differences in fuel oil consumption tabulated in the reports. These large variations were unsatisfactory to the individual undertakings concerned and they were not pleasing to the Association as a body. The Com-

mittee decided to obtain independent analyses of samples of various oils obtained from users and to compare these. The analyses, which were made without disclosure of the names of the suppliers, showed, as was expected, widely different characteristics in the oils. The Committee then invited Mr. Harold Moore, a well-known analytical chemist and oil authority, to discuss these matters with them, and eventually to put forward specifications embodying characteristics which would ensure a first-class heavy oil engine oil, without including any highly expensive feature, and which it would be practicable for the great majority of oil merchants to supply.

Altogether thirteen samples of lubricating oil, used by members of the Association, were analysed on behalf of the Committee. The extreme limits of difference discovered were :—

Specific gravity at 60° Fah.	·880 to ·934
Closed flash-point	375° to 450° Fah.
Viscosity in Redwood seconds—	
At 70° Fah.	644 to 1942
At 100° Fah.	244 to 634
At 140° Fah.	97 to 225
At 200° Fah.	47 to 76
Cold test	15° to 40° Fah.
Saponification value	Nil
Colour	Very dark green to a clear red

All the samples tested were pure mineral oils.

The Committee recommends the following two specifications :—

Specifications for Lubricating Oils for use on Heavy Oil Engines. (Diesel and other High-compression Types.)

	2 and 4-stroke cycle heavy oil engines.	
	Specification A. 100 to 240 r.p.m.	B. Above 240 r.p.m.
Specific gravity at 60° F. ..	Not exceeding ·885	·882
Closed flash-point	Not below 400° F.	400° F.
Viscosity in Redwood seconds—		
At 70° F.	Not exceeding 1250	700
At 200° F.	Not less than 56	50
Cold test or pour point ..	Not higher than 35° F.	35° F.
Colour (by transmitted light)	Clear red	Clear red

The oil shall be a straight mineral oil
Method of testing—Inst. Pet. Tech.—No tolerances allowed

It is suggested that if the majority of the members will make an extended trial of oil purchased to these specifications, comparative results of much value to the Association and its members will be obtained, and that future tables of working costs will show greater uniformity. The specifications cover oils which are suitable for all purposes on a heavy oil engine, excepting that for some air compressors it is desirable to use a slightly compounded oil.

At the conclusion of its investigations, the Committee invited representatives of the principal firms of lubricating oil suppliers in the country to attend a meeting, so that they might have an opportunity of expressing their opinions on the specifications. The general opinion expressed at that meeting was that the specifications were of such a character as to provide for a first-class lubricating oil suitable for use with heavy oil engines, which it would be possible to supply at reasonable prices.

An Improved Marine Reverse Gear.

THE marine reverse gear which is shown in the accompanying illustrations, is one of three Langdon "Titan Special" gears which have been supplied by the Langdon Engineering Company (1924), Ltd., of Northam, Southampton, for installation in a new motor yacht for Earl Fitzwilliam. The yacht was recently launched at the yard of Camper and Nicholson, Ltd., of Gosport. It will be propelled by triple screws, each driven by a 225 brake horse-power Ricardo type petrol motor, through the reverse gear to be described. The cylinder diameters are 6¾in., with a stroke of 7½in., and the power is developed at a speed of 1200 revolutions per minute.

During a recent visit to Southampton we inspected one of the gears which had just finished its shop test. It was run light by belting from the main line shafting, and it performed its reversing functions in a silent and effective manner, responding quickly to any movement of the control hand wheel. We saw the gear after it had been opened up, and all parts of it were shown to be in good condition and well lubricated. The principal object of the present article is to call attention to some of the improvements which have been made to this new model, which represents the firm's latest type of reverse gear. As to its mode of operation, the general principle of the gear remains unaltered. The engine drive is transmitted through a double plate type clutch to the reversing drum and the after shaft. When running in the ahead position the drive is direct, and it is transmitted through a small number of thick plates, which are arranged in the forward part of the clutch casing, and which assist to take up the drive with greater ease and smoothness. The thick plates represent a considerable improvement in the design, inasmuch as they allow the gear to slip if it should be engaged very suddenly in the ahead direction with a racing engine. Equally, when the direction of rotation is reversed suddenly, with the propeller, say, out of the water, no damage can be done either to the gear, the engine, or the shaft, for the reverse gear, being operated by a band brake, engages quite smoothly under all conditions. At the after end of the clutch casing a larger number of thin plates are fitted with the object of giving a powerful grip. The clutch grip is further assisted by the pressure of the cam rollers—attached to the forward pressure plate—on the cam pieces formed on the after pressure plate.

The alteration in the direction of rotation of the after shaft is effected by a triple train of reversing pinions which are housed within the reversing drum. They are shown in the sectional drawing—Fig. 1. These pinions come into action when the drum is held stationary by the band brake which encircles it. It will be seen that the reversing drum is placed directly under the control column. At the end of the central spindle—which is geared to the control hand wheel—a solid cam is provided, which engages with the bronze sliding end pieces of the brake band. A brake lining of special friction material is provided. The end pieces—see Fig. 2—are so designed that they slide one within the other, and so draw together both of the ends of the brake simultaneously in a manner which avoids any side thrust. Provision is made for adjusting the tension in the band by means of a screw and a locknut, access to which is given by the removal of a small inspection cover.

The makers claim that the new method of brake operation eliminates any effect of wear, whilst there is no strain put upon the spigot bearing at the centre of the gear. For these reasons, the design is one, it is claimed, which enables the gear to be run astern at full speed and under full load for periods of from one and a-half hour to two hours.

It will be seen that a double ball thrust bearing and two supporting bearings are fitted at the after end of the gear, whilst forward of the main casing is a roller bearing, a feature which, we understand, has given great satisfaction in practice. Ball thrust bearings are also fitted where the clutch lever applies the pressure through the solid steel operating pins to the clutch plates. At either end of the gear casing are packed glands to prevent the escape of lubricating oil.

Some important changes have been made in the main parts of the clutch. By constructing the after pressure plate and the forward clutch cover in steel and making these parts from solid forgings, the necessity for keying has been avoided and a stronger and simpler construction is thereby obtained. Accessibility has evidently been taken carefully into account, both as regards the main casing of the gear and the control column. The latter part is so designed that it can be lifted off of the main casing intact, the gear-operating spindle being only centred and dropped into a square shaped hole in the forging, which forms the combined ahead and astern cams. This being done, the top casing can be entirely removed, exposing the whole of the internal parts of the gear—as shown in Fig. 2. The assembled reverse gear, as seen from the astern end, is illustrated in Fig. 3.

Particular attention, we are informed, has been given to the question of efficient lubrication. With the centre parts revolving at a high speed, it is evident that lubricating oil will tend to be thrown out from the centre of the mechanism. For this reason holes are provided in both clutch covers, so that the plates are evenly lubricated by the oil collected by centrifugal action. The reversing pinions are furnished with special oil ducts, while the external bearings are all separately fed from an oil box which is mounted on the control column.

With a view to testing the performance of a smaller but similarly designed reverse gear, a trial was made early in the present year at the Yeovil Works of Petters, Ltd. The Langdon gear was coupled direct to a 12 to 14 brake horse-power single cylinder Petter crude oil engine running at a normal speed of 515 revolutions per minute. The engine had a 26in. diameter fly-wheel 6in. wide, and coupled to the gear, which was arranged at the opposite end of the engine to the fly-wheel, was a 26in. diameter brake drum. The gear was run ahead at top speed and the operating hand wheel was then swung hard over to astern. Immediately the drum slowed down, stopped, and then started to run in the opposite direction. The same sequence of movement took place when the hand wheel was moved from full speed ahead to full speed astern, and in all cases, we are informed, the take up was very smooth. The performance of the gear was, we learn, equally good with the drum loaded, and the direction of rotation was reversed several scores of times during the period of the test. Also, no slip was registered. After the test the gear was dismantled and assembled again in one and a-half hours, and in spite of the rough usage no indications of damage were to be found.

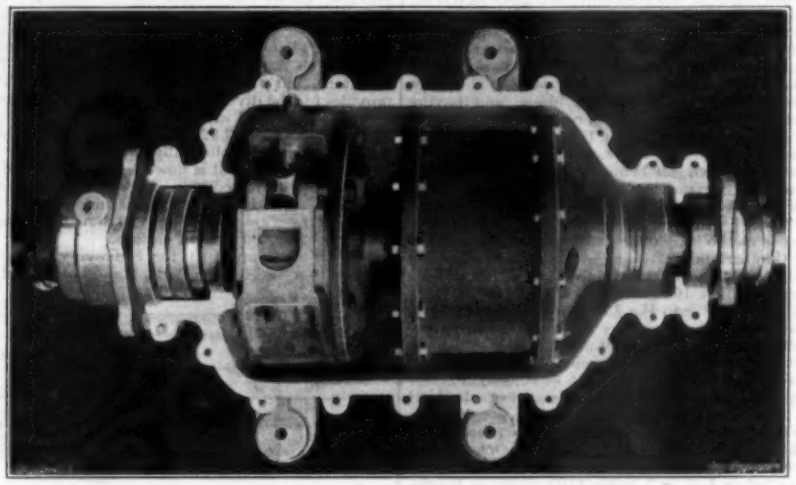


FIG. 2—GEAR WITH THE UPPER HALF CASING REMOVED

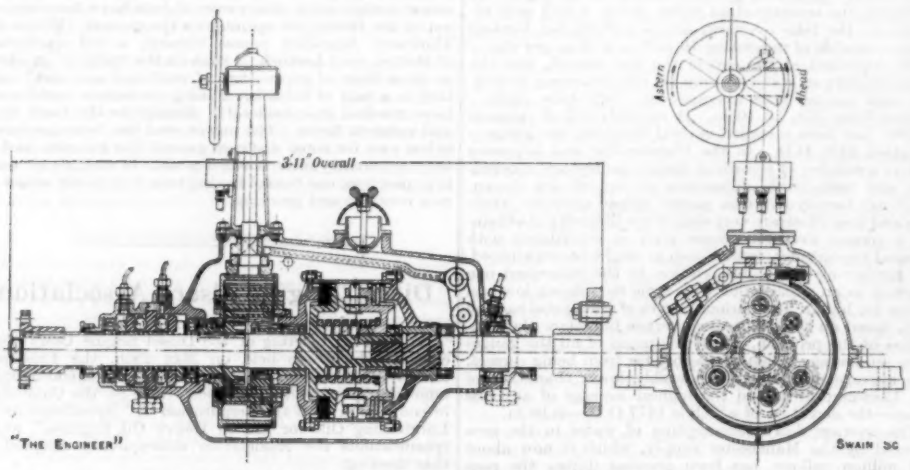


FIG. 1—ARRANGEMENT OF THE LANGDON MARINE REVERSE GEAR

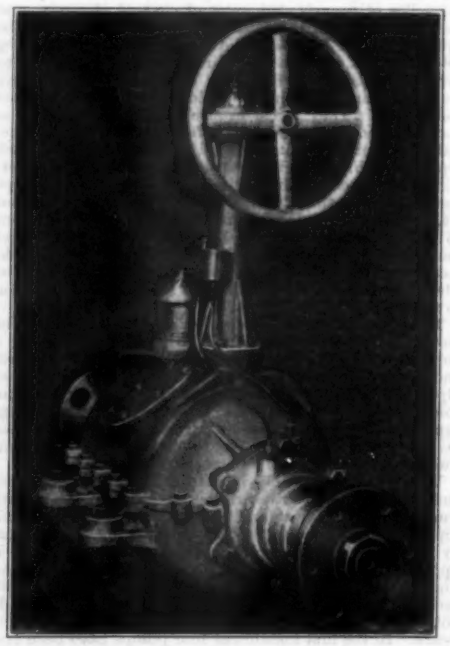


FIG. 3—END VIEW OF THE GEAR

It is of interest to learn that this British made gear is being supplied to several British engine builders and also to marine motor builders in Scandinavia and other places abroad.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

COAL AND ECONOMICS.

SIR,—With reference to your article on the above subject, I would like to call attention to those chapters in the Samuel report which deal with subsidiary companies. These companies, in which the mineowners often have large interests, return substantial profits to the collieries, which are not reckoned as proceeds for the ascertainment of the miners' wage.

It is true the report does not reveal this as existing to a very wide extent in the particular form described on page 92—*i.e.*, selling agencies connected with a group of collieries; but there still remains *nominally* outside the owner's scope, the activities of the factors, the wholesale merchants, retailers and the exporters.

As to these the report says:—"There may be room for reducing the number of cases in which a factor intervenes"—page 89—and, the total margin required by the retail merchants in their expenses and profits is described on page 87 as "disquieting." Further on—pages 88–89—retail establishment charges and clerical salaries are described as excessive, and if these could—in London alone—be reduced to the level of the Co-operative Society, a substantial margin would be available for "increasing wages to the miner!"

The chapter on profits—page 217—is very short, and it may be summed up as "wrapt in mystery," tor you have such expressions as these:—"It is impossible to get satisfactory information" and "the complexity of the matter renders it impossible to make an exact statement," "royalties to landowners are also equal to an average charge of two shillings per week upon the wages of every man and boy employed in the industry," page 110.

It is considerations such as these which have led the Commission to recommend that "before any sacrifices are asked from those engaged in the industry, it shall be definitely agreed between them that all practicable means for improving its organisation and increasing its efficiency should be adopted"—page 229.

In plain words an artificial frontier has been erected across what is and should be clearly recognised as a single domain, viz., the coal industry. The dividing line has been drawn at the pithead price, and evidence exists that those who own the pits are able to make arrangements whereby they can get a share of the difference between the pithead and the selling price, whereas the miner cannot.

Because the miner and his leaders see this they are accused of preaching class hatred, they are told their intellects are "warped," that these arrangements are laws "just as impregnable as physical laws," and that he will be the first to suffer if he does not obey.

These same leaders put before the Samuel Commission a lucid and statesmanlike scheme of unification for the industry which should make engineers feel envious. True the Commission turned the scheme down as being, in their opinion, unworkable, but they commented favourably upon many of its features and recognised that there was "substance in the demand which their scheme was intended to meet." Many of these features are embodied in the Commission's own alternative plans.

On the other hand, they flatly disapproved of every suggestion made by the Mining Association—page 235—thereby confirming your expressed opinion that they were more sympathetic to the collier than to the mineowner.

The first paragraph of your article is genial and pleasant reading. Its tone is excellent, but the intellect gets a bad jolt when we reach the statement that human and economic problems can be separated! Throughout the second paragraph there is a series of further jolts, but the mind simply reels, totters and collapses completely when the climax of the shining argument is reached with the extraordinary conclusion that "economic laws are just as impregnable as physical laws," and that the miners are called upon to "obey a law which it is outside the power of man to control," and get back to work quickly before they starve first themselves, then the whole country.

Labour leaders may have "warped intellects" in spite of the fact that many of them have held high positions with credit to the State, but it is very much to be doubted whether even the worst educated amongst them would propound so superficial a fallacy.

Shall we apply the acid test? We may postulate that the Press is a fairly great industry, and assume for the moment that the journalists, upon whom circulation depends, perform as necessary a service to the State as the miner performs. The proceeds of the industry fall into two categories, the sale of the paper itself and the income from advertisements. I am told that if the journalist's remuneration was limited to the proceeds from sales alone, his standard of life would have to be reduced, and in some cases he would be obliged to starve unless he was capable of performing some other service.

Is that a human or an economic problem? Would their "power of detachment and ability to look at economic problems without personal bias" rise to such an occasion? Surely not. The argument may glitter like gold when applied to miners, but it is shown to be base metal when the acid is applied.

No, Sir, there is no law, legal or economic, that is independent of the human will, and if a man or body of men desires to render what they consider a necessary service they find ways and means of turning economic laws to their service in the same way as we engineers turn natural and physical laws to the service of the race.

One of the laws most familiar to engineers is that "energy always flows from a high to a low potential." If he is faced with the apparently impossible task of making water run up a hill, he promptly applies his knowledge of that law and creates artificially an apparatus which produces the necessary potential difference and the job is done.

In economics the familiar and fundamental law is known as that of supply and demand; but it can be made subservient to the human will in exactly the same way as is illustrated above. The journalist, faced with the apparently impossible task of making a living by writing, sets about creating a potential difference.

How does he do it? He tells a tradesman that his writings are so much sought after that many people desire to read what he says, but they are not willing to pay enough to satisfy him, and subtly suggests that he—the tradesman—might find it profitable to attract the attention of his readers by an announcement.

He thus creates a commercial temperature difference, so to speak, and trade begins. Energy flows from one to the other, and the Press have managed this part of their business so successfully that in some cases it is said they could give the paper away; but the point is, that by organising and co-ordinating his efforts with others, and only in this way has it been possible for him to flourish as a journalist.

The fundamental problem is *entirely human*, and the economic fact which the community must face is the miner himself, and we do not deserve to be free from continual strife until this is recognised, and recognised handsomely.

Engineers must examine these problems steadily and see them as a whole, remembering that before science made them engineers, great nature made them men.

J. GOLDER, M.I. Mech. E.

London, June 3rd.

[We are gratified by Mr. Golder's consideration of our article but we should have been more pleased had he not taken a line here and there from a condensed argument and converted it to his own purpose. For example, we did not specify the miner and his leaders in our reference to "warped" intellects; we were careful indeed to refer to both parties, whoever they may be, in our condemnation of class hatred. There is no "statement" as such that human and economic problems can be separated. The sentence to which our correspondent refers is presumably, "The problems with which we are faced are not human problems at all, but purely economic problems," and the exact meaning of the words is made clear by the context. The economic law is that if you cannot sell at a certain price you cannot sell at all. Our correspondent acknowledges the law himself but believes, as we understand him, that it can be put into operation by attacking selling costs. On that point he has a right to his opinion, but we would point out that the Commission saw no way of re-establishing the economic position quickly but by a reduction in the cost of coal *production*. We regret that Mr. Golder himself should have so little power of detachment that he not only brings in his own personal bias on one side but, quite unjustly, accuses us of it on the other.—ED. THE E.]

AN UNPUBLISHED LETTER BY WILLIAM JAMES.

SIR,—Students of the history of the modern railway system will be glad to hear more of the very scanty records of that mysterious personage who was acknowledged by Robert Stephenson, Locke, Brunel, Rennie, and others to have been the original projector and surveyor of the Manchester and Liverpool and many others of the most important railways in the kingdom (*vide* "The Two Jameses," page 106).

The writer has just had an opportunity of reading the following letter, one of the last known to have been written by James, and written only three months before his death. There are certain words that are very difficult to decipher, but, for the most part, the letter (written in old-fashioned style on four pages of a quarto sheet of notepaper folded and sealed with his initials) is written in a clear, bold, and rather picturesque handwriting and addressed to Mr. John Kirshaw, by favour of Mr. Povey. Mr. Povey would be one of the Poveys of Warwick, well known there as formerly agents of the Earl. Mr. Kirshaw appears to have lived at Lapworth near James' birthplace, Henley-in-Arden.

The letter, written at the age of sixty-five, runs as follows:—

Bodmin, 14 Decr., 1836.

My dear Sir,

I feel I am taking a liberty in addressing you, but the claims of an tried friendship will I hope not be forgotten, and whatever difference there may be in our situation, no difference in our . . . esteem has I trust taken place. Although it is probable we may never meet again, my health, distance, and debilitany years appear to announce that fact, yet I am desirous you should not be mistaken as to the motives of my conduct in respect of my own affairs—all power having been taken out of my hands and transferred to the Assignees and their Solicitor by this most dreadful Commisn.

[It is only thro' and to them, that win my opinion could have been offered =]*. Knowing that fact, and having had every sovereign drained from me by my first family, how useless, how hopeless, would have been any effort at interference, more especially when it is considered that I must have given up much time (which till this last few years was very valuable) to those affairs.

I was knocked down, and have been kept down. My fine property which under my own management I flattered myself would have given me an ample fortune, thro' expenses, debtors & other circumstances will not I hear pay the demands of my just creditors which is to me a most affecting circumstance as I hoped that thro' disgrace of this comm, added to the 14 years deportation from my concerns and native land in consequence of shame at my altered situation would have been diminished if not removed the stain by paying all my just debts.

I fear some unprincipled claims have been made and some errors exist as to debts. I never saw a list nor any of the accounts which I hear are to be audited on Saturday.

I have written a letter to Messrs. Corrie & Carter for permission on my return eastward to examine and extract from these accounts & I hope the creditors will pass a Resolution to that effect. Will you have the goodness to use your interest for the purpose.

I have heard (though I know not the fact) that the bankrupt is entitled to some allowance. When I came to be examined on Whitman Jones business the sum paid me was not sufficient to defray my expenses, and on that occasion Mr Corrie lent me £20 for which he holds my Note but which he demanded of me which very much distressed me as from the Advaces to Walter and others, I was unable to pay it. Mr. Bill also lent me £10 on another occasion. These sums I am very anxious to pay. My situation even as a Bankrupt is peculiarly unfortunate as not having any friend or advocate between myself and the Commrs who I am certain are disposed to do me justice. Permit me to request that friendly office[1] of you at these two meetings.

I have sustained most ruinous losses in Mr * * * * and Mr * * * * * * * * absconding to France where they are living in stile. My demands (much out of pocket) amount to above £900, tho' I hold something like security. I have offered to accept £500. Thank God I do not sink or despair I shall overget all these rubbs, I have great hopes before May, but at this time, if the Bankrupt is entitled to an allowance the advance of a hundred pounds on the credit of it would relieve my mind greatly by paying Mr Corrie and Mr Bill and give £70 to myself. Will you be so good to attend to this for me at the Meeting.

As to my General Prospect I think it has much improved within the last 12 months. I open an office in London in Jany as a Land Agent and Consulting Engineer. I have three views into futurity which at present appear flattering, and as my unhappy children have disposed of every article of Furniture & Memorial of my name & family, I am, as it were, sold out by them, & I must begin the world anew. Oh, God! I have been most cruelly treated. But no more. I am truly rejoiced to hear of the Welfare and Respectability of your children, and of the health of yourself and your good Wife.

Yours very truly, W. JAMES.

P.S.—In my Examn of Accounts I merely want to ascertain the Amounts that the clear produce under the proper heads may be obtained by me. But if you think my personal offices may begrieve anyone, I do not urge it, or if I have the power to inspect and abstract I would not urge it. The Advance is very material as my children at Birmingham are almost without the necessaries of life—God knows by their own folly. I have paid £50 from my quarterly payments on the day, besides a large Advance to Walter. They would never be advised.

This letter was endorsed by Mr. Kirshaw "Last Letter," and after it was written the Mr. Corrie above mentioned urged James to come to Warwickshire and investigate his affairs, assuring him that even then he might save £30,000 for his family. He had decided to accept the advice when he caught cold in travelling outside a stage coach and died of influenza. March 10th, 1837, at Bodmin. S. J. A. COTTERELL.

June 4th.

* Some words apparently missing.

BATS *VERSUS* MOSQUITOES.

SIR,—In the review of my book, "The Engineer and the Prevention of Malaria," in your issue of June 4th, the writer rather suggests that "the nerves of the ladies" is my chief argument against the dependence on bats for the extirpation of the anopheline mosquito. In the next paragraph to that quoted by the reviewer I say: "Grassi reports that the most malarious parts of Italy are those that have the densest bat population." Dr. Campbell's work is of great interest, but I believe I am right in saying that the United States Health Service, which has an intimate knowledge of the doctor's work in establishing bat-roosts and the effect of bats in reducing the mosquito population, does not recommend the bat as even a palliative measure in anti-malarial services, and indeed is sceptical as to its value as a natural enemy of the mosquito. A tract was published by the Department on this subject which I have read, but have not with me as I write.

In "Mosquitoes and Coconut Palms," by Dr. W. E. Haworth ("Transactions" of Royal Society of Tropical Medicine and Hygiene, 1924, October, Vol. XVIII., No. 4), under "General Conclusions," appears the following:—"The natural enemies of the mosquito, in all its stages, so far as observed, are inefficient; the harmful species have been found developing from the larval stage to the perfect insect in the presence of *M. brevipalpis* and *L. tigripes* larvæ; and *Aëdes* larvæ have been brought from crowns (of coconut palms), the resting places of numerous bats."

My own experience in Central America and Africa is that bats have no appreciable value as an anti-malarial instrument, and I should not recommend their employment even though there be a convenient belfry.

HENRY HOME.

London, S.W. 7, June 4th.

INSTITUTION OF WATER ENGINEERS.

THE thirty-five annual general meeting of the Institution of Water Engineers was opened in Manchester on Wednesday, when Mr. L. Holme Lewis, M. Inst. C.E., M.I. Mech. E., waterworks engineer to the Manchester Corporation, was elected President. In the course of his opening address Mr. Lewis made reference to the need for further research, which, he said, as far as it related to waterworks engineering, was left largely in the hands of inventors. That was not as it should be, and advocated the support of the water authorities by a scale of contributions towards the cost of setting up and maintaining a branch of the Royal Scientific and Industrial Research Department for dealing with matters relating to water supply. He also advocated that the Institution should become more active in its efforts to promote legislation on matters affecting the water interests of the country.

With regard to the future, Mr. Lewis remarked that at no time had the country experienced a period of greater uncertainty than the present. That fact placed a greater responsibility upon the water engineer, who was relied upon to meet the growth in demand for water, and at the same time to avoid expenditure on schemes of extension in advance of actual requirements.

After the presidential address, Mr. W. F. H. Creber, M. Inst. C.E., read a paper on "The Manchester Waterworks," of which an abstract is given on page 614; and other papers were contributed on Thursday on "Water Supply Finance," by Mr. A. W. Kenyon, and "Some Metallurgical Problems of the Waterworks Engineer," by Mr. W. E. W. Millington. The annual dinner was held at the Midland Hotel on Wednesday evening, and the remainder of the week is being devoted to visits to the Manchester waterworks at Thirlmere and Haweswater.

THE "Bank" telephone exchange closed down on Saturday, June 5th. It was the first London Exchange to be fitted with a multiple switchboard, and the last to be worked on the "magneto" principle. This obsolete method of calling the attention of the operator by turning a handle and ringing a bell has now passed for ever. In point of numbers, the Bank was the smallest of the London exchanges, having less than 1000 subscribers, who will now be transferred to the Central exchange.

A New Sand Blast Barrel.

It not absolutely essential, it is at least desirable that machines and appliances for use in foundries should be as simple and robust as possible in construction so that they may withstand the rough handling and heavy duty to which they are liable. In this respect the new sand blast barrel illustrated in Figs. 1 and 2, of which J. W. Jackman and Co., Ltd., Vulcan Works, Manchester, are the makers, can fairly claim to be a decided improvement. The body consists of a double casing A A made of steel plate. The inner casing is perforated to allow the abrasive material to drop into the annular space, whence it passes through the totally enclosed trunnion B to the cleaning box C at one end of the barrel. This arrangement presents the advantage that no dust or abrasive material can get on to the rollers D, thus eliminating the severe wear which has hitherto been a common defect in sand blast barrels. The end plates E E are of cast iron with machined treads,

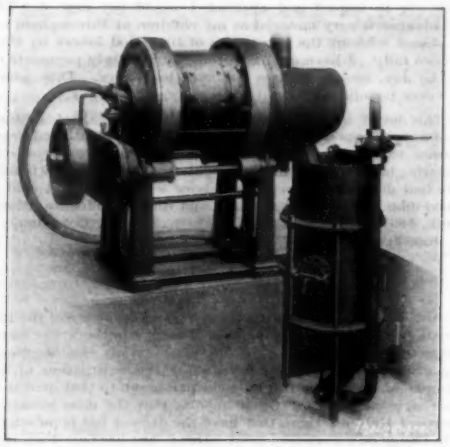


FIG. 1—JACKMAN SAND BLAST BARREL

by which the barrel is carried on the four rollers D keyed to gear-driven shafts, the gear wheels being totally enclosed, as seen in the half-tone view. The drive is effected by a belt and single pulley F controlled by a clutch G. Access to the interior of the barrel is gained through an air-tight door. The barrel is supported on two frames mounted on a cast iron base plate, and as it has no surrounding casing and no elevator, charging and emptying are easily performed.

The abrasive material and dust pass, as already mentioned, through the hollow trunnion into the cleaning box. There screening takes place and the dust is drawn off by a fan to the separator, while the cleaned material ready for re-use passes to the pressure apparatus. The tailings, consisting of nails, sprigs, &c., are discharged from the cleaning box.

The pressure apparatus consists of an upper chamber H, into which the abrasive material is continuously fed from the barrel and a lower chamber J under pressure, from which chamber the abrasive material passes through a control valve K into the delivery hose. The construction of the valve K is such that wear is claimed to be eliminated.

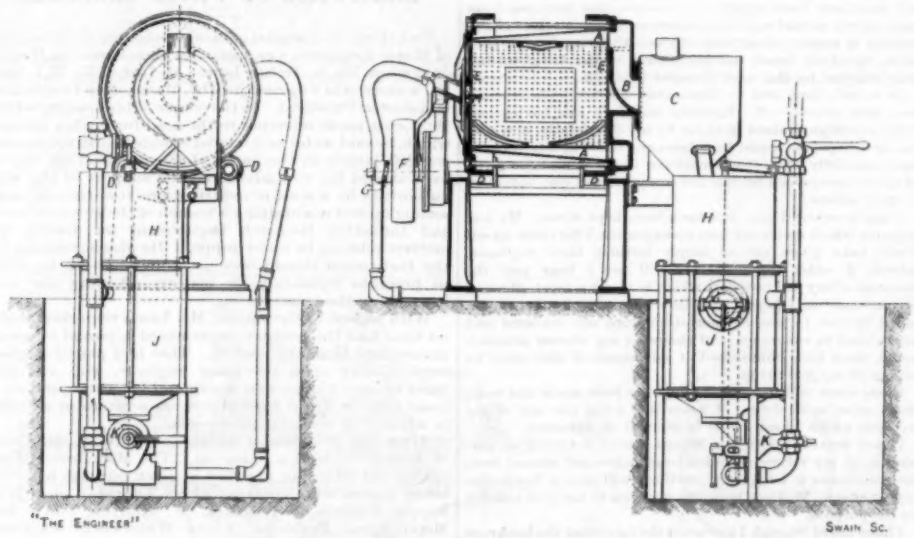


FIG. 2—ARRANGEMENT OF SAND BLAST BARREL

The valve is positively controlled by means of a handle and cam device, and a simple clamp enables it to be dismantled. The nozzle M is fitted into the end plate at one side of the barrel, and it, too, can be quickly removed.

The machine is built in two sizes, namely, with 18in. and 24in. barrels.

It is noteworthy that the extensions of the boiler plant at Shell Haven belonging to the Shell-Mex Company are to be fired with pulverised coal, whereas the present boilers are oil fired. Three boilers, each of 42,000 lb. per hour capacity, are to be fitted with Lopulco pulverised fuel burners.

South African Engineering Notes.

Rand's Record Output.

The gold mines of the Witwatersrand and outside districts established by their March operations a record output for the industry. The yield for the month was 834,340 fine ounces, an increase over February of 80,416 oz. This remarkable total is the direct and immediate effect of a marked improvement in the native labour position. There were at the end of the month over 181,000 natives employed on the mines, an increase of nearly 10,000 in two months, the January total being 171,985 and the February figure 178,311. The March record output surpassed the previous best by nearly 4000 fine ounces. The actual record up to then was held by March, 1912, with an output of 830,723 fine ounces. That total, however, was largely assisted by a special clean up, but even with that advance it was surpassed by March's output by 3617 fine ounces. Excluding March, 1912, the nearest approach to the 1926 record was in July, 1924, when the output returned was 829,437 fine ounces.

The total mineral output of the Union for March was valued at £4,753,795, against £4,316,981 for February. The total value for the first three months of 1926 is £13,595,485. The following are the principal items for March month :—

		Value. £
Gold, oz.	824,285	3,543,823
Silver, oz.	82,691	11,370
Osmiridium, oz.	274	6,223
Diamonds, carats	230,448	773,270
Coal, tons	1,098,064	329,423
Copper ore, tons	1,011	50,762
Tin concentrates, tons	84	14,669
Asbestos, tons	1,282	20,958
Soda, tons	89	956
Corundum, tons	92	825
Chrome ore, tons	1,178	473

Lead ore, iron ore, graphite, iron pyrite, magnesite, mica, mineral paints and talc were also responsible for smaller amounts.

Expenditure on Rolling Stock.

The Railway Administration of the Union of South Africa has just furnished details of the expenditure which has been incurred year by year since the end of the financial year, 1921, for the acquisition of new engines, trucks and coaches :—

	Engines. £	Trucks. £	Coaches. £	Totals. £
1921–22	187,000	—	632	187,632
1922–23	3,538	25,368	8,131	37,037
1923–24	235,929	357,120	10,161	803,210
1924–25	25,317	582,158	1,513,606	2,121,081
1925–26	778,151	474,796	837,046	2,089,993
Authorised.				
1926–27	1,232,412	826,307	987,355	3,046,074

The position at date with regard to engines, trucks and coaches authorised but not yet placed in service is as follows :—Engines : There are 129. With the exception of five electric engines, which are only due for delivery towards the end of the year, the whole of the balance of the engines authorised, namely, 124, should be in service by the end of the current year. Coaches : There are 654 coaches on order or to be ordered. It is anticipated that a good proportion of these vehicles will be available for service by the end of the year. Trucks : A grand total of 2076 trucks of various types are on order or to be ordered or being built in South Africa. Of the number 1000 grain wagons should be in service by June or July next. Delivery of 500 four-wheeled steel drop-sided wagons should commence in November, and they should be in service five to six months later. There are 170 steel drop-sided bogie wagons of 80,000 lb. carrying capacity, delivery of which should commence in July next. It is anticipated that the whole of these vehicles will be in service by September or October. Details of the balance of the trucks on order are as follows :—38 bogie refrigerator fruit wagons ; 25 four-wheeled fruit wagons ; 15 four-wheeled refrigerator wagons for dairy traffic ; 10 four-wheeled ventilated wagons for dairy traffic ; 10 bogie water tank wagons ; 50 bogie goods vans ; 150 bogie fruit wagons ; 20 76-ton coal wagons ; 70 50-ton hopper trucks ; 18 bogie petrol tank wagons.

Aviation Service in South Africa.

Owing to the persons who a while back entered into a tentative agreement with the Union Government to establish a civil aviation service in South Africa not having fulfilled the terms of the agreement, it has now been declared by the Government that the matter is at an end. It appears that the company approached the Government and endeavoured to get the subsidy of £8000 per annum, which the Government had promised, increased, and also wished for a monopoly for ten years and minor concessions. The position now is that it is again open to any company or individuals to come forward with proposals for the establishment of a civil aviation scheme in the Union, as a commercial undertaking. The Government is still prepared to devote a sum not exceeding £8000 per annum to assist in starting aviation in the Union, if acceptable proposals are made providing reasonable guarantees of an efficient scheme.

Rand-Cape Telephone Service.

A long-distance trunk telephone service between Johannesburg and Cape Town was officially opened in April. The charges—15s. 6d. for a three-minute call—are high, but it is anticipated that they will eventually be reduced. In any case, the advantages of such a service are obvious, and its employment is bound to become increasingly popular.

Irrigation in Great Fish River Valley.

The policy of the Union Government of advancing in loans large sums of money is bringing about excellent results in most cases, though, in a few, rash embarking in ambitious schemes has had disastrous results, and the financial losses have been heavy. One very successful enterprise has been the irrigation of over 24,000 morgen—a morgen is about 2 acres—of highly fertile land in the Great Fish River Valley. Many settlers from Britain have availed themselves of the opportunity of acquiring a small plot of ground there on which to make their homes, and there is room for many more, for full advantage of the possibilities of the valley has not yet been taken.

It was in 1912 that interest was awakened in the great irrigation possibilities of this valley. Flood irrigation schemes were undertaken by bodies of farmers, who formed irrigation districts and obtained loans from the Government wherewith to construct their schemes. To-day, there are no less than eight of these works with their diversion weirs to lift the flood waters from the river and feed the network of canals. It was found, however, that these works, acting purely as flood water schemes and drawing water only when the Great Fish River was in flood, were too dependent on the uncertainties of flows in the Karoo Rivers, which often pour down to the sea before full use can be made of them. Thus, at the request of the irrigators, the Government came forward and constructed two large conservation dams on tributaries of the Great Fish River. Now Grassridge dam, on the Great Brak River, 9 miles to the east of Conway Station, with a storage capacity of 63,500 acre-feet, serves land on a river frontage of 61 miles, and Lake Arthur, on the Tarka River, 16 miles east of Cradock, with a storage capacity of 75,300 acre-feet, serves land on a river frontage of 117 miles. Five schemes supplied by the Grassridge dam have a total area of 10,121 morgen, or 21,344 English acres. They have been in successful operation since February, 1924, and were of great advantage to those who were fortunate enough to be able to draw water during drought periods. The Grassridge reservoir filled last year, and an era of prosperity is assured to the irrigators.

Lake Arthur, named after H.R.H. Prince Arthur of Connaught, who laid the foundation stone in November, 1923, is now completed, and recently held up 52,300 acre feet of stored water, with which to carry on during the present year. It serves nine subsidiary flood-water schemes, the distributory works of which have been in operation since 1916. These nine schemes represent a total of 14,692 morgen. Both Grassridge and Lake Arthur dams have wide expanses of water, stretching back 6 or 7 miles above the impounding walls.

These schemes were commenced in the days when ostrich farming was at the zenith of its prosperity, and lucerne was the main crop raised. Since then other crops have been laid down, such as wheat, oats, and potatoes, &c. Latterly, the potentialities of fruit growing in the valley have been realised, and around Longhope very extensive orchards have been planted. A fruit-drying factory has been built, and this year started operations. There would appear to be a very prosperous future for the greater part of the Fish River Valley in fruit growing, drying and canning for the export market. Judging from the report of the Irrigation Finance Commission which made suggestions in connection with the settlement of land in the Great Fish River Valley, there will be great strides in development made in the near future.

Narrow-gauge Motor Truck.

The Union railway workshops at Pretoria recently completed the construction of a narrow-gauge motor coach for the Port Shepstone-Harding line in Natal. With the exception of the engine, which is of the Leyland type, the entire work was carried out locally. The body is mounted on a steel underframe, which measures 28ft. 6in. over buffers. It is arranged with a four-wheeled bogie at the front end and a radial driving bissel at the back. The diameter of the leading bogie wheels is 1ft. 8in. and of the trailing bissel wheels 2ft. The wheel base of the leading bogie is 4ft., and the distance from the centre of the bogie to the centre of the radial bissel is 18ft. Buffers are provided at each end of the underframe and a cow-catcher is fitted to the front end. The total weight of the vehicle is 6·36 tons. Tanks are provided to carry a supply of 50 gallons of petrol. The engine is of the four-cylinder Leyland pattern, commercial type, developing 48–60 horse-power. The clutch is of special design, being of the double dry disc type balanced. The gear box is arranged for four speeds

forward and backward. The car is electrically equipped throughout, having a self-starter, dynamo, batteries and a full lighting system for the coach and headlights.

The coach body is divided into four compartments. The driver's compartment is arranged to accommodate one first-class passenger, while two other compartments provide seating accommodation for sixteen first-class passengers. The fourth compartment is arranged to take either ten second-class passengers, or the seats can be lifted up and the compartment used for the conveyance of baggage.

World's Largest Electric Hoist.

An exceoptinally large electric winding equipment is shortly to be installed for No. 4 shaft of the City Deep Gold Mine. The hoist is designed to lift a net load of 9½ tons of ore from a depth of 4500ft. Thirty-one loads per hour will be delivered at the surface, the speed of winding being 3707ft. per minute, or more than 40 miles per hour. The winder is to be driven by a direct-current motor with a maximum peak-load capacity of 12,500 horse-power. The motor will be direct coupled to a bi-cylindro-conical drum, varying from 35ft. to 17ft. diameter. The Ward-Leonard system of control is being adopted, current being supplied by two 2000-kilowatt generators driven by an induction motor of 5200 horse-power.

Some idea of the large size of the plant can be gained from the dimensions and weight of the principal units. The double motor, for instance, is nearly 20ft. diameter with a bore of 16ft., and weighs about 300 tons. The drum shaft weighs over 50 tons, while the drums themselves weigh about 350 tons and carry 18 tons of rope. The installation of this remarkable piece of machinery shows the determination of the technical directors of the gold-mining industry to practise what they so unceasingly preach to the rank and file. Efficiency is the keynote of the industry and accounts for the remarkable progress achieved during the last few years, notwithstanding the loss of the gold premium. It can be added, with satisfaction, that the hoist and everything appertaining to it is British made.

Consumption of Gas and Electricity in Johannesburg.

The following statistics regarding the increased consumption of electricity and gas in Johannesburg have been made public by Mr. B. Sankey, the general manager of the municipal gas and electricity undertakings. The figures given actually deal with the years 1920 to 1925, both inclusive, but it will be sufficient here to quote the data for the initial and final years only. In 1920 the consumption of electricity was 32,951,801 units; in 1925 the units sold were 50,260,665. The revenue in 1920 was £357,239, and in 1925 £439,382, while profits increased from £51,355 to £74,313 in 1925. The latter amount was, however, less than for 1924, which was £85,422, the decrease being due to the abolition of the post-war increase and the supply being now given at pre-war rates. The works costs per unit sold were ·6878d. in 1920 and ·4457d. in 1925. The total capital outlay in 1920 was £1,214,355, and at the end of 1925 had risen to £1,669,887.

The consumption of gas in 1920 was 63,334,348 cubic feet and in 1925 88,435,527 cubic feet, while for 1924 it was 81,045,132, but the consumption in 1925 would have been many millions more had the plant been capable of supplying, as it is the almost daily applications of hundreds of prospective private consumers and industrial concerns have to be turned down as they cannot be supplied. The revenue from coke and tar in 1920 was £11,059 and was £15,009 for 1925, the revenue from gas sold in 1920 was £18,150 and in 1925 was £26,197. The net profits for 1920 totalled £7022 and for 1925 £17,713. The cost of manufacture per 1000 cubic feet sold was 4s. 5d. in 1920 and 3s. 3. 73d. in 1925. The total capital outlay in 1920 was £40,068 and in 1925 had only increased to £44,474. The present plant is extremely antiquated, and when the new plant is erected very great economies will be found possible.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Trade Situation.

THOUGH in several directions production of iron and steel in the Midlands and Staffordshire is still maintained in all departments, the effects of the coal shortage are being more severely felt. In addition to the growing scarcity of fuel, South Staffordshire industries have to contend with an increasing shortage of materials. Most of the factories are on short time, and trade is gradually diminishing. It is remarked that the iron and steel trades have stood the test of the strike much better than seemed possible from the business point of view. A good deal of buying and selling has taken place up to now, and there is plenty of evidence of a future demand for iron and steel sufficient to maintain the expanding rate of production, which has been a feature since the beginning of the year. Stocks of material are, however, now coming to an end, and there is little coming on to the open market, available iron and steel being reserved for regular customers. The attendance at the weekly meeting of the Midland iron trade in Birmingham to-day—Thursday—was poor, and little business was transacted. Conversation centred on the prospects of an early agreement between the mineowners and their employees, and hopes were expressed that an end would soon be found to this disastrous and protracted conflict. Valuable orders are being lost to this district, which would provide many weeks, if not months, of work for local firms, and increasing quantities of foreign raw material are being made up in Staffordshire works, where formerly native material was used. Even those engineering establishments which could carry on, are restricted in power with consequent loss of output and working hours.

Steel.

A few steel furnaces in the Midlands continue at work, generally dependent on producer gas or on gaseous fuel of some kind. This class of work is, however, exceptional, the general activity being restricted to isolated mills in different districts, usually electrically driven. A fair total of mills are at work in South Staffordshire, many firms finding it possible to operate single mills. For the products of such plants Birmingham and local trades provide a ready market. Constructional engineers continue to receive invitations to tender for work, in some cases thousands of tons of steel being involved. The local bridge-building yards and rolling stock works are continuing much as usual, although inconvenience is caused by the delay in railway deliveries. Values all round are firm. Something better than the basis price is required for plates to cover the cost of rolling from cold ingots. Small supplies of steel sections are obtainable. A figure 5s. to 10s. over the minimum rate of the Association is paid by constructional engineers, who have contracts which they are anxious to complete. Other consumers unwilling to concede these prices are making use, for the time being, of continental material. Unfortunately, the strike has given an opening to foreign steel makers, who are taking large contracts for the supply of steel to this country. The slump in the franc has assisted in bringing foreign prices to very low levels, joists, for example, being offered at £5 18s. delivered against the local official price of £7 2s. 6d. Increasing quantities of this foreign steel are being employed in building structures. Belgian plates also are offered at £6 7s. 6d. delivered against the native figure of £7 17s. 6d., and they are being imported in larger quantities. The Staffordshire re-rollers have been buying foreign steel somewhat heavily, the present low prices being decidedly attractive. Some contracts arranged cover several months' requirements, and much foreign business has been placed through Birmingham merchants for shipment to foreign destinations. The willingness of buyers to contract on this scale is fairly strong evidence of the confidence with which future business is regarded.

Raw Iron.

Midland furnaces are now idle, and stocks of pig iron are nearly all sold. Firms holding any reserves restrict their sales strictly to regular customers. Prices easily maintain their recent increase; but the trade discourages anything having the appearance of profiteering. Quotations are, to a great extent, nominal. There are only one or two furnaces in the Midlands that have any material to offer. Small lots of foundry pig have been sold this week at £3 12s. 6d. to £3 15s. They were not offered on the open market, however. A Derbyshire house, which raised its quotation a week ago to £3 10s. for No. 3 required 5s. more to-day, and the price was paid. The remaining remnant of stocks is being dealt out very sparingly. Trade in forge iron may be said to have ceased. Foundries, however, are carrying on largely with the aid of scrap, the worst pinch being in connection with the dearth of fuel.

Manufactured Iron.

There is no change for the better in the Staffordshire finished iron trade, and on 'Change in Birmingham to-day—Thursday—there was practically no finished iron of native production on offer. Until fuel is forthcoming the mills must remain idle. Continental bars for use in the nut and bolt industry were on offer at about £6 2s. 6d. delivered Darlaston, and those works in operation placed fairly substantial orders for supplies chiefly with Belgium mills.

Galvanised Sheets.

Business in galvanised sheets continues and good contracts are being placed. Some mills are booking orders for July and August delivery, subject, of course, to strike exigencies. Fairly good business has been negotiated with overseas buyers. There is little change in prices. Quotations range from £15 10s. to £15 15s. for 24-gauge galvanised corrugateds. A few Staffordshire mills continue to operate.

Strip.

Strip mills are supplying the local tube makers with raw material, and a steady output of tubes is reported. No change has been made in the Staffordshire basis of £10 10s. for strip at works.

Scrap.

Steel scrap is unsaleable. Much material has been held up in transit, buyers declining to receive consignments.

Works Extensions.

It is gratifying to learn that Messrs. Goodyear and Sons, now associated with the Dunlop Company, are contemplating important extensions to their Dudley works, which will "absorb a very considerable number of the unemployed in the town." It is another indication that, if only this wretched industrial dispute could be settled, a return to prosperity might very soon be realised.

Coventry Engineering.

The Coventry motor engineering industry is suffering in common with other trades as a result of the miners' strike. This is forcibly illustrated by the unemployment returns. Two months ago there were only 908 people unemployed in the city; to-day the number on the register is 4332, of whom 3400 are men. Moreover, there is no indication that the retrograde movement has been checked, but rather the reverse, for during the past week the number of unemployed has again increased by about 160. What earlier on gave prospects of a record year is now likely to turn out, if not a failure, at least a very different affair to what had been anticipated.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

WITH each week that the mining stoppage continues the more pronounced are its industrial consequences. The iron and steel industries were the first to bear the brunt, and trade in the products of these industries has now reached such a pitch of stagnation, primarily because they are not to be bought so readily owing to dwindling stocks, that a worsening of the position from what it is at the present time cannot easily be conceived. How long it will be before the engineering industries become ensnared in the mesh is a matter for conjecture. Those that depend upon municipal power supplies have not been very seriously affected up to now, but more rigid restrictions than those already in force will be inevitable if a settlement of the coal dispute is much longer delayed. Many foundries, however, are experiencing to a serious degree the effects of the coke shortage, and some of them have had no alternative but to close down altogether, while the most favourably situated from the point of view of fuel supplies have only limited stocks in hand that will enable them to keep going for two or three weeks. Two Lancashire firms—Taylor Brothers and Co., Ltd., Manchester, and the Pearson and Knowles Coal and Iron Company, Ltd., Warrington—are among the concerns sharing in the big contract for wagon wheels and axles just placed by the London and North-Eastern Railway Company. An interesting development in this district with a direct bearing on the engineering industries is the agreement between the Metropolitan-Vickers Electrical Company, Ltd., Manchester, and the American concern, the General Railway Signal Company, which provides for the manufacture of railway signalling apparatus at the former company's Trafford Park works.

Non-ferrous Metals.

Among the non-ferrous metals, tin alone has had a really weak time during the past week, the steadier feeling referred to in my last report having soon exhausted itself. Stocks in this country are not heavy, but against this have to be set the much-reduced buying operations during the last month or so, further bearish influences being the big increase in the visible supply at the end of May by 3600 tons to 17,700 tons, or roughly 20 per cent. above the end of April figures, and fairly heavy selling pressure. A slight recovery from the worst point resulted from an improvement in the volume of buying on United States account, but the position on balance represents a fall of nearly £40 per ton from the highest level reached this year, and at the time of writing weakness is still a characteristic of the market. United States stocks of copper are relatively low, and with the early prospect of the new Copper Export Association commencing operations—the end of the current month is mentioned as the appointed time—prices have kept pretty steady throughout the week and continue so at the present moment. Spelter has been maintained, with a slight recovery of the ground lost in the previous week, whilst lead, under the influence of improved buying on continental account, chiefly for Germany, is quite a firm section of the market.

Iron.

The iron market, from the point of view of pig iron supplies, has now reached a critical stage. So many producers of pig iron have been compelled to withdraw offers entirely that one is forced to the conclusion that little or no free material will be available in the near future. The position seems to be now that stocks held by those firms who had specifications in hand are fast approaching the safety limit. Certainly the task of those consumers who are seeking supplies on the open market is by no means an easy one, for the position is so difficult this week that the producer cannot be found who is prepared to give a price for deliveries of standard qualities. About 80s. per ton, delivered in the Manchester area, for Derbyshire No. 3 pig, was the price I last quoted. Last Friday the quotation had advanced to 82s. 6d., and now it is more or less an unknown quantity. Up to 87s. 6d. has been mentioned as the figure which was the basis of the sale of a small stock parcel. As regards manufactured iron, the price position seems to be unchanged, Lancashire Crown bars still being quoted at £11 per ton and second quality material at £9 15s. per ton, including delivery into the South Lancashire district. The stocks of this are fairly good, and sales are moderate. With one or two exceptions where work is being carried on for a day or two a week, most of the forges in the Lancashire district are still stopped.

Steel.

There is very little fresh that can be said about the steel position this week. Actual business is on a very restricted scale and constructional engineering firms in this area, many of whom are satisfactorily situated as regards work in hand, are having difficulty in getting hold of the material they want. A large volume of orders is held by the mills, mainly specifications against contracts, but these, of course, are held up until the time when a resumption of operations is possible. In the meantime, there is still no change in the Association prices for joists and sections, plates and bars, but in view of the dearer pig iron and possibly higher fuel costs when things are again normal, a revision of steel prices in an upward direction is regarded as inevitable. Galvanised sheets keep steady at from £15 10s. to £15 15s. per ton f.o.b., but there has been little fresh business of any weight put through during the past week. Prices quoted for continental steels on the Manchester market remain easy, with Siemens plates on offer at £6 7s. 6d. to £6 10s. per ton, ordinary plates at £6 to £6 2s. 6d., joists at £5 12s. 6d., sections at £5 17s. 6d. to £6, and steel bars at about £5 17s. 6d., delivered into this area, for cash against documents.

Scrap.

The demand for iron and steel scrap is on a very small scale, and values are largely nominal at the moment,

ordinary machinery cast iron scrap being at about 62s. 6d., textile machinery scrap at 67s. 6d. to 70s., wrought iron at 60s. to 62s. 6d., and mild steel scrap at 50s. to 52s. 6d., on truck Manchester. Non-ferrous scrap is quiet, but there has been little change in the level of values. Lead is about £27 10s., zinc £24, braziery copper £49, clean light copper £57, cast aluminium £84, and selected heavy yellow brass £44 10s. for graded qualities, delivered to users' works.

BARROW-IN-FURNESS.

Waiting.

The North-West district is waiting for the coal troubles to be settled, and then there is some hope of business getting on to a level road. Time after time, for the last five years or more, just when there was a promise of better conditions prevailing in the pig iron trade, a cloud would appear on the horizon with the result that customers have held off placing orders, save those for immediate requirements, and eventually there was a damping down of furnaces to allow of stocks which had accumulated being cleared. Never during the period mentioned has the trade in this district been clear of impediments. Once or twice there has been an occasion when there have been promises of a good run, but sooner or later some trouble has cropped up, and confidence has been swept out of the market. Now, if the coal industry comes to a sound basis of agreement, there seems some chance of the iron trade coming into its own. In the meantime, there is a gradual clearance of stocks so that, when there is a start, there will be practically nothing to begin upon. The hoop works keep going and have enough fuel to assure continued activity for some time. All power comes from the Barrow electric supply. During last week there were dispatches seawise of hoop iron for Alexandria (*viâ* Liverpool), Birkenhead and Mombasa. Accompanying the hoops to Mombasa were rails and fish plates which were turned out at Barrow a few weeks before the stoppage.

SHEFFIELD.

(*From our own Correspondent.*)

Works Coming to a Standstill.

No open-hearth steel was produced in the Sheffield area last month, and the district now presents the deplorable sight of nearly a hundred huge furnaces standing idle. The iron and steel industry in North Lincolnshire is also keenly feeling the effects of the coal stoppage, though the general manager of the Normanby Park Steel Works, Scunthorpe, has drawn attention to a notable achievement on their part. With the exception of a short period during the general strike, the Normanby Park Works of John Lysaght, Ltd., have kept their blast-furnace plant continuously running. Up to the end of May they had three of their largest furnaces in operation, at the present time two are in blast, and it is hoped that these will continue working for some time to come. They are now engaged on the manufacture of special foundry iron. A comparatively small amount of crucible steel has been made in Sheffield since the industrial trouble began, and the supplies of coke are now almost exhausted. The rolling mills are practically at a standstill, and it is only possible to do a little forging and casting work. Orders in all branches of the iron and steel trade have dropped off, which is only natural in view of the prevailing conditions; but, in spite of this, manufacturers could be a good deal busier than they are if only they could get freer supplies of fuel and other raw material. Not only has there been an enormous increase in the applications for unemployment pay, but the Sheffield Guardians, for the three weeks ending May 31st, had an additional 4478 applications for relief, 1672 from miners who wanted relief on loan, 2176 from persons in other occupations wanting relief on loan, and 632 from persons who would, but for the stoppage, have been at work. Ordinary relief has also gone up with a bound, owing to the fact that previously self-supporting persons have become workless.

Engineering Departments.

There has been a dearth of engineering items since the commencement of the coal dispute, and a good deal of engineering work that would have been placed has either been suspended until trade conditions become more settled, or, in the case of urgent business, it has gone abroad. This district, however, gets a share of the latest railway order to be placed by the London and North-Eastern Railway Company, which requires 13,000 tons of British steel rails. Among the firms to participate are Steel, Peech and Tozer, of Sheffield, whilst an order for 4400 pairs of wagon wheels and axles goes to the Leeds Wheel and Axle Company, Owen and Dyson, Rotherham; J. Baker and Co., Rotherham; Cravens Railway Carriage and Wagon Company, Sheffield; and to firms in other parts of the country who have working arrangements with the large engineering steel works of Sheffield. Since May last year a joint committee has been inquiring into foreign competition and conditions in the shipbuilding industry with a view to finding out why continental yards can so severely underquote British firms in tendering for shipbuilding contracts. Last October an interim report was issued, and the complete report will be published shortly, after it has been presented to a meeting of the Executives of the shipyard trade unions at York on June 18th. At this conference new facts relating to costs outside the shipbuilding industry, but entering into the cost of the completed ship, will be made public. The whole question is one in which Sheffield firms have a very deep concern.

Large Russian Orders.

Substantial orders for files, saws, edge tools and steel have been received in Sheffield from Russia. This work will take several months to complete, and in view of the fact that the general trade orders are good, there is every prospect of these tool branches having a busy time when fuel supplies again become available in full. Last year similar Russian orders proved extremely valuable to Sheffield firms, particularly to those making files, and the delay in repeating the orders this year has caused considerable disappointment. The work would have been very acceptable a few months ago when all the lighter steel branches were complaining of lack of work. The orders that have now been placed are substantial, but are nothing like so large as those received last year. This is not because Russia is not in need of those steel products in which Sheffield specialises. The evidence that Sheffield manufacturers have is that there is urgent need for all classes of machinery and steel goods, but the country is too poor financially to incur further liabilities. Manufacturers have proof of this in the offer of additional business on very long credit terms. As already indicated, the prospects for the lighter trades are excellent, but at the moment comparatively little work can be done owing to the shortage of fuel supplies. Fortunately, electricity and gas for power purposes are still available in reasonable supply. It is only possible to work on a restricted basis in the cutlery and plate factories, and there is a marked shortage of orders.

Parkgate Iron and Steel Company.

Mr. Charles Markham, presiding at the annual meeting at Sheffield of the Parkgate Iron and Steel Company, gave some interesting figures relating to six South Yorkshire collieries for the month of April, which was a broken period. They raised 450,000 tons of coal and paid £229,000 in wages, or 10s. 2d. wages for each ton. That was divided among 18,000 workmen. Mr. Markham further mentioned that during the past few years they had lost at Parkgate in strikes nearly £200,000. That money had gone to nobody, it had brought in no revenue, and it had brought nothing but misery and hardship.

Pit Development Workers.

An agreement has been arrived at with the Notts Miners' Association which allows for the development of the new Ollerton Pit of the Butterley Coal and Iron Company to be proceeded with. A deputation from the men asked the management to allow them to return to work, and the Miners' Association subsequently agreed to issue permits to about eighty men to return. The pit has now been reopened.

Oil Instead of Coal.

Oil fuel plant was installed at the Leeds tramway power station at Crown Point during the last dispute, and it is again proving useful in the present emergency. Six of the eight boilers are now being fired by oil, though normally each one is a coal boiler. In an eighteen hours' day, the six boilers burn 18 tons of oil, and the daily coal consumption has by this means been reduced from 65 tons to 30 tons.

Increased Rail Charges.

Sheffield Chamber of Commerce has received a report from the Railway Matters Committee on the question of the proposed increase in the companies' "exceptional rates" from their present level to one of 60 per cent. above the pre-war rates, plus the "class" rates, and the withdrawal of the present maximum additions to the base rates. It was felt that it would be a very serious thing for the industries of Sheffield, in view of the fact that such a large proportion of the traffic of the city was carried under "exceptional rates" if the proposals were accepted by the Railway Rates Tribunal. The representative of one Sheffield firm stated that the proposed increase would involve an additional cost to them of between £20,000 and £23,000 in one year, and it would mean that much long-distance low-class traffic would be impossible in the future.

Local Coal Position.

Sheffield is fortunate in having a steady supply of gas and electricity, and its coal supplies, too, appear to be more favourable than those of other large centres. Mr. G. C. Brooks, the Coal Emergency Officer, reports that they are quite comfortable from the householders' point of view for the immediate future. An appeal has been made for industrial supplies to be conserved to the utmost. The Sheffield Gas Company reports that it can provide a supply for several weeks yet, despite the fact that the supply of gas taken from the coke ovens was cut off almost immediately after the strike commenced. Outcrop seams are being extensively worked in this district, and a good deal of fair-quality fuel has been obtained from that source.

NORTH OF ENGLAND.

(*From our own Correspondent.*)

The Trade Situation.

THE industrial position in the North of England grows daily more serious, and unless there is a speedy settlement of the coal dispute, there will be complete stagnation. The stringency in regard to fuel supplies is now being seriously felt, and it is only with considerable difficulty that some of the small iron foundries and engineering establishments are being kept in operation. How much loss has arisen through contracts being cancelled or held back it is impossible to say, but it is certain to be stupendous. The only gleam of comfort to be obtained among so much depression, is the fact that there is an undertone of confidence in commercial circles, that with the settlement of the coal trouble there will be a long period of peace and stability. It is hoped, and in fact believed, that Labour will eventually settle down, and that with confidence restored there will be a genuine expansion of trade. Such a course remains to be proved, but, at any rate, it is the natural inference to be drawn from the trend of events.

Paralysed by Strikes.

Very serious harm has been done to the Port of Middlesbrough as a shipping centre, as the result of a series of strikes during the past five weeks. When the general strike was called off the dock workers on the Tees declined to sign the national agreement, and they refused for nearly a fortnight to resume work. After considerable injury had been inflicted on the trade and commerce of the district, an agreement on almost identically the same terms which the men had originally refused was come to, and work was resumed at the docks and wharves. The tugboatmen, however, declined to accept the terms offered to them at the conclusion of the general strike. As a result, several tugs were manned by volunteers, and vessels brought into the dock. The dock workers then passed a resolution that any shipbrokers employing tugs manned by voluntary labour should be penalised in respect of any ships which they might have been working in the docks. Two cargo liners were taken out of the docks on Sunday morning last, and on the Monday morning the men refused to discharge two other vessels in charge of the same firm of shipbrokers. The London and North-Eastern Railway Company decided to close the docks immediately, and the workers, numbering 1000, were in effect locked out. Within a few hours, however, the tugboatmen accepted the terms of the employers, and the lock-out order with regard to the dockers was withdrawn. All sections of workers returned to work on Tuesday.

Cleveland Iron Trade.

The situation in the Cleveland pig iron trade is very difficult, and everything depends on the turn of events in the fuel trade. Stocks of coal and coke have shrunk to very small proportions, and if supplies are not forthcoming in the very near future plant, which has been kept in operation up to now, will have to be laid idle. There is a marked scarcity of iron, and that scarcity must tend to become more and more acute as existing stocks approach the point of exhaustion. That point is already approaching, and it is now only possible to buy very small quantities. The output of the few furnaces still in operation is all being promptly absorbed, and no expansion is possible till the coal strike ends. Yet curiously there is a remarkable feeling of confidence in the industrial outlook, if only the settlement at the mines is not delayed until industry is completely prostrate. Buyers are quite keen to place forward business, and even a further rise of 1s. per ton, making an increase of 5s. since the general strike, in the prices of Cleveland pig iron has not entirely checked them. But faced with a probable increase in working costs, producers are bound to pursue a very cautious policy indeed, and they are sitting tight, selling only small parcels to old customers. Market quotations now are:—No. 1 Cleveland foundry iron, 78s.; No. 3 G.M.B., 75s; No. 4 foundry, 74s.; and No. 4 forge, 73s. 6d. These are home quotations, and nominally export prices are 6d. per ton more, but these figures are prohibitive to foreign buyers, and no export business is being done.

Hematite Pig Iron.

There has not been a corresponding rise in the price of East Coast hematite, because stocks are more plentiful, and mixed numbers are being sold in small quantities to the Continent, in addition to steady home sales. Still the advance in Cleveland iron tends to stiffen the price, and most sellers of mixed numbers are now asking 78s., with No. 1 quality at 78s. 6d. per ton.

Ironmaking Materials.

There is no market for blast-furnace coke. Best Rubio ore is still nominally 21s. 6d. per ton c.i.f. Tees, but consumption having almost ceased, no new business is being put through.

Manufactured Iron and Steel.

A fair number of inquiries are reported in the manufactured iron and steel trade, but stocks of all descriptions are low, and little business can be put through. Producers have not yet formally advanced prices, but are not inclined to sell at the old figures.

Iron and Steel Imports.

Statistics presented at this week's meeting of the Tees Conservancy Commissioners showed that the imports of iron and steel from continental countries, India, and coastwise for the seven months ending May 31st last amounted to 122,405 tons, as compared with 101,176 tons in the corresponding period of 1924–25, and 42,718 tons in the pre-war period of 1913–14. Imports of pig iron for the past seven months reached 37,935 tons, as against 7215 tons a year ago, and 181 tons in the pre-war period. Crude sheet bars, billets, blooms and slabs imported to the end of last month amounted to 76,012 tons, as compared with 78,958 tons a year ago, and 27,413 tons in 1913–14. The imports of plates, bars, angles, rails, sheets and joists for the past seven months totalled 8458 tons, as compared with 15,003 tons in 1924–25, and 15,124 tons in the pre-war period.

Tees Shipyard Closed Down.

As an indirect result of the coal strike, the Tees shipyard of Smith's Dock Company, Ltd., was closed down on Wednesday night. The closure of the shipyard does not extend to the engine works or the dry dock, nor is it in any sense due to lack of work. The firm has a fair number of orders to execute, and latterly it has been employing between 600 and 700 men. The stoppage of the local steel works through the coal strike has, however, had the effect of holding up supplies of essential materials—plates, bars, &c., and, as a consequence, the firm has reluctantly been compelled to close an establishment which has worked continuously since it was first opened seventeen years ago.

The Coal Trade.

There is no movement in the coal trade. Each day's delay is enabling foreign competitors to secure the whole continental summer trade from customers in all districts. When the home output restarts shippers expect a very lean time for some months to come, and in the mean-

time they are compelled to turn down all inquiries for supplies over the second half of the year, until such time as they know definitely the terms of the settlement, for prices will be mainly governed by them.

SCOTLAND.

(From our own Correspondent.)

Drooping Activities.

WITH the continuance of the coal strike, activities are so much reduced that business is now almost devoid of fresh interest. Many producers of all description of material have been forced to curtail, if not to suspend operations, and actual orders passing are extremely few, owing to the impossibility of naming delivery. In view of the latest move in the coal dispute, hopes of a settlement have been renewed, but general opinion can hardly be termed optimistic.

Steel and Iron.

Only a few of the Scottish steel works were re-opened after the collapse of the general strike, and owing to diminishing stocks of fuel, the number still in operation will soon be materially reduced. Even where works are open the plants employed are running far below capacity. Practically all the large steel works are idle, a notable exception being the works at Mossend, which were re-started in order to provide material for the company's tube works. Only three of the eight works owned by the bar iron combine are open, but other works producing similar material are in operation. Steel sheet makers are well placed for orders. Bar iron works have sufficient fuel to last another couple of weeks, while steel sheet makers can still carry on for upwards of three weeks yet. Since the strike began the number of pig iron furnaces in blast has been reduced to four, compared with about eighty-five in normal times. Bar iron and pig iron are said to be somewhat firmer in price, but in the absence of business firm quotations are impossible.

Shipbuilding Orders.

Clyde shipbuilders are hopeful of receiving orders for a number of the steamers to be built for the Canadian Pacific Railway. Mr. Beatty, president of the C.P.R., who has arrived in Britain in connection with the placing of contracts for two passenger and five freight steamers, has been reported to have said that it was almost certain that the two passenger boats would be built on the Clyde, and very possibly the cargo vessels also. The passenger steamers will be 600ft. in length and 17,500 tons, while the freight steamers will be 10,000 tons. The total value of the orders will be £3,000,000.

Coal.

The coal market is practically a dead letter. Supplies—even the household ration—are almost impossible to secure. Substitutes are freely offered, but in view of the continued warm weather the demand is very limited.

Coal in Bute.

Several times within the past fifty years attempts have been made to locate seams of coal in the island of Bute, and in the neighbourhood of Ascog in particular. In a field on the Ascog farm a seam was found in the year 1912, but the coal was not in sufficient quantity to justify a continuance of operations. Recent borings undertaken by Mr. Colin Campbell, the owner of Ascog farm, and Mr. William Ryan, mining engineer, hold promise of some success. Coal has been drawn from this seam in sufficient quantity to justify further operations. The few men employed have been able to produce about 1 ton of coal per day, and the fuel is said to burn well and to have good heating properties.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Coal Position.

THERE is, of course, no business for export so far as the coal trade is concerned. Everything is at a standstill, and all firms which are in any way interested in the coal industry, whether for export or otherwise, are feeling the strain of the position. All sorts of proposals are being put forward as a solution of the present *impasse*, but it is generally recognised that a real and proper settlement must now be arrived at, as the leeway to be made up will be tremendous. Although every development in the situation is being very closely watched, grave fears are entertained that there is a distinct possibility of there being no work in the coalfield before the end of this month or even early next. The stoppage has already been of sufficient duration to cause very great anxiety to all coal-owners and exporters respecting markets abroad. If the suspension of work in the coalfields of the country continues for several weeks longer it is pretty certain that the export trade from this district will be very seriously damaged for the next six months. Last week between forty and fifty vessels were chartered to carry foreign coal, of which close on 180,000 tons was American coal. Of this quantity, just over 100,000 tons was destined for this country. All the information coming to hand points to the strenuous efforts which the foreign producers are making, not only to get into, but to secure a strong grip on the markets of the world. In the case of Italy, one correspondent states that a leading American firm is sending special engineers and firemen, paid by it, to the different industrial concerns which have purchased its coal, in order to teach them how to handle the fuel. In many instances all the alterations to be made in the boilers, &c., in order to use better the American coal are to be made at the expense of the American firm. Apart from the fact also that the prices quoted for American coals are lower than those for Welsh coals, both German and American sellers are giving every facility as regards payment; ninety days is the minimum allowed, while for many buyers 120 and 180 days' payment are conceded.

Coal Supplies and Employment.

The control of all available coals is more drastic than ever, in view of the prospects of the continuance of the stoppage in the coalfield, and it is not surprising in the circumstances to find that all the tin-plate and steel works in this district are experiencing greater difficulty in carrying on. Most of them, as already announced, are either altogether on stop, or are only working in a few departments. Supplies of small coals have been released more freely by the Control Committee, with the consequence that patent fuel undertakings have been able to resume at both Cardiff and Port Talbot. Also in other centres fairly substantial quantities of patent fuel are being produced. There is a pretty big demand for this commodity for domestic use, and the price is fixed at 32s. 6d. at works. The manufacturers cannot produce at less than this figure, owing to the operations at the works being intermittent. Supplies of patent fuel are also obtainable in approved cases as bunkers for steamers, in which case the price is 33s. 6d. per ton f.o.b. In one case, in which bunkers were not permitted for a Spanish vessel which had been held up in Cardiff since the beginning of the strike, the owner sent to the Channel another of his steamers which had taken on board an extra quantity of bunker coals at Gijon, North Spain, and last week supplies were transferred to the steamer which had been lying at Cardiff, so that she was able to get away to Rotterdam.

Craftsmen's Position.

Speaking recently at Porth to members of the Rhondda Joint District Colliery Enginemen, Boilermen and Craftsmen's Association, the general secretary stated that no proposals affecting their wages had yet been made to the Association. Under no circumstances would any suggestion tending to depress wages be acceptable to the Association, as it had taken a definite stand that the pre-strike wages of workmen in the Association were far too low.

Siemens Steel Trade.

At a special meeting at Swansea on Friday last of the Siemens Steel Association Joint Board, the Vice-chairman, Mr. Frank Rees, said the effect of the general strike and the action of the Iron and Steel Trades Confederation joining it was nothing less than a tragedy so far as that industry was concerned. The employers had been for some time fighting day by day and hour by hour to retain the trade. The action of the men in stopping the works had made it impossible for the employers to execute the orders they had on their books and had incurred them such losses that it would be impossible for them to carry on the sliding scale percentages and ex gratia bonuses as in the past. Mr. John Hodge, on behalf of the men's organisation, unreservedly admitted that a wrong had been committed in violating the constitution of the Board, and he gave the fullest possible assurance on behalf of his organisation that in the future the constitution would be loyally abided by. Later, the Joint Standing Committee of the Board met and considered claims, the most important matter being that respecting the bonuses. For some time past the men have been paid 20 per cent. on the base rate under the sliding scale, and, in addition, an ex gratia payment of 30 per cent. has been allowed to the lower paid men. After a long meeting the two sides failed to agree, though it is understood that the employers are putting into operation the sliding scale of 10 per cent., but are increasing the ex gratia bonus so as to safeguard the position of the lower paid workmen and boys under eighteen years of age.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.

THE following preliminary programme of arrangements for the summer meetings of the Institution of Heating and Ventilating Engineers at Scarborough on June 21st, 22nd and 23rd has been issued :—

On Monday, June 21st, at 5.30 p.m., there will be a Council meeting at the Grand Hotel. On the Tuesday morning at 9.30 a.m., there will be a general meeting in the Council Chamber, Town Hall, and in the afternoon, at 3 p.m., a motor tour, by invitation of the Mayor and Corporation, to places of interest in the town, including Oliver's Mount, the war memorial, the bathing pool, the Italian gardens, the marine drive, Peasholm Park, and the Alexandra Gardens. At 4.30 p.m. there will be a reception at the Town Hall by the Mayor and Mayoress of Scarborough (Councillors Geo. and Mrs. Whitfield). At 6.30 p.m. a banquet will be held at the Grand Hotel. An entertainment by members and friends will follow the banquet.

On the Wednesday morning, at 9.30 a.m., a photograph will be taken on the terrace at the Grand Hotel, and at 9.45 a.m. there will be a motor drive to Whitby *vid* the Goathland Moors route, returning by the coast route. At 12.45 p.m. luncheon will be taken at Hotel Metropole, Whitby, by invitation of the President. At 3 p.m. the party will leave the Hotel Metropole by motors for Scarborough, arriving at the Grand Hotel at 4.30 p.m., when afternoon tea will be served, by invitation of the President.

Catalogues.

HIGGS MOTORS, Witton, Birmingham.—Stock list for April-May, 1926, of A.C. and D.C. motors.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancashire.—General descriptive catalogue of the firm's products.

BEECROFT AND PARTNERS, Ltd., St. Peter's Close, Sheffield.—A booklet entitled "A Handbook for Foundrymen and Engineers.

STITSON, WHITE AND CO., Ltd., 102, Victoria-street, S.W. 1.—A descriptive record of some of the contracts carried out in recent years.

DOWDINGS' MACHINE TOOL COMPANY, Ltd., Bush House, Aldwych, London, W.C. 2.—Illustrated catalogue of machine tools, Bush series.

THE ELECTRICAL CONSTRUCTION COMPANY, Ltd., Ingersoll House, Kingsway, W.C. 2.—Third edition of the booklet entitled "Modern Electrical Plant."

C. A. PARSONS AND CO., Ltd., 56, Victoria-street, S.W. 1.—The steam turbine section of the series of catalogues describing Parsons' power installations.

MARSALL, SONS AND COMPANY, Ltd., Gainsborough, Lincs.—Publication No. 1628 dealing with the "Marshall-Cummer" asphalt plants and accessories.

ATELIERS DE CONSTRUCTIONS ELECTRIQUES DE CHARLEROI, Route de Philippville, Charleroi, Belgium.—List of motors and dynamos in stock on May 1st, 1926.

K. HOLST AND CO., 1, Victoria-street, S.W. 1.—Booklet illustrating and describing various types of ferro-concrete structures designed and erected by the company.

DELCO-REMY AND HYATT, Ltd., 111, Grosvenor-road, London, S.W. 1.—Booklet describing the Delco-Remy system of coil ignition, entitled "Specifications do Count."

B. AND S. MASSEY, Ltd., Openshaw, Manchester.—Catalogue No. 3000B, giving illustrations and particulars of pneumatic power hammers, their accessories and performances.

SUPER-CENTRIFUGAL ENGINEERS, Ltd., Aldwych House, W.C. 2.—Postcard illustrating the motor liner Asturias, upon which is installed a battery of four Sharples oil purifiers.

MARRYAT AND SCOTT, Ltd., 57, Hatton Garden, E.C. 1.—Book entitled "Lifts," illustrating and describing many types of lifts installed in hospitals, hotels, and industrial buildings.

THE DAMARD LACQUER COMPANY, Ltd., Warwick-road, Greet, Birmingham.—General descriptive booklets on "Formite" Bakelite moulding material, its uses and methods of moulding.

DAVID BRIDGE AND CO., Ltd., Castleton, near Manchester.—Souvenir of Bridge's rubber plantation machinery for 1926, illustrating various plantations and describing the machinery used.

GEORGE ELLISON, Perry Bar, Birmingham.—List No. 327 dealing with totally enclosed brake solenoids or power magnets; also catalogue of totally-enclosed brake solenoids or power magnets.

WAILES DOVE BITUMASTIC, Ltd., 5, St. Nicholas' Buildings, Newcastle-on-Tyne.—Booklet describing some of the structures coated with "Bitumastic" solution as a preventative against corrosion.

TILGHMAN'S PATENT SAND BLAST COMPANY, Ltd., Broadheath, near Manchester.—Catalogue illustrating and describing the various types of sand-blasting apparatus made and the uses to which it can be put.

THE ENGLISH ELECTRIC COMPANY, Ltd., Queen's House, Kingsway, W.C. 2.—Publication No. 757 entitled "Transformers for 110,000 Volts," describing twelve transformers supplied to the Tata Power Company for use in India.

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, East Pittsburgh, Pa., U.S.A.—The following illustrated leaflets: —L 1520, A, "Selection of Motor Gearing, Varying Speed Motors"; L 1530, Class 11-160 and 11-165, "Across-the-Line Type Magnetic Starters with Thermal Cut-out Overload Protection"; L 10,025, "Babbitts and Solders"; L 20,188, "Type K O Current Transformers, 4600 volt Service"; L 25,405, "Type R Expulsion Fuses, Outdoor form 5400 to 110,000 volts."

LAUNCHES AND TRIAL TRIPS.

DOMINIA, cable-laying steamer; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of the Telegraph Construction and Maintenance Company; dimensions, 300ft. by 59ft. beam; to carry 12,000 tons deadweight. Engines, twin-screw, triple-expansion steam; constructed by the builders; trial trip, June 2nd.

AMBROSIO, oil tanker; built by Harland and Wolff, Ltd., to the order of the Lago Shipping Company, Ltd.; dimensions, 315ft. by 50ft. broad; 2360 gross tonnage. Engines, twin-screw, triple-expansion type, pressure 180 lb.; constructed by the builders; launch, June 3rd.

IMPROVISED OIL BURNING.—In view of the coal stoppage, Alexander Duckham and Co., Ltd., 6, Broad-street-place, E.C. 2, have drawn up a short memorandum on oil firing which should prove useful to those who find their coal supplies running out. With the memorandum is included a working sketch of an improvised oil burner, which can be made in a few hours from the kind of material that is to be found in any works, at the cost of a few shillings. The firm will be glad to send copies of this memorandum and sketch to anyone who is interested. We may add that the memorandum is not an advertisement, as Alexander Duckham and Co., Ltd., have no interest in fuel oil supplies at the moment.

THE INSTITUTION OF FUEL ECONOMY ENGINEERS.—At a Council meeting of the Institution of Fuel Economy Engineers, held in London on Friday, May 28th, it was decided that the following observations be forwarded to the hon. secretary of the proposed Institute of Fuel Technology:—"The Council is unanimously of the opinion that professional qualification for full membership of a national fuel institution is vital for the existence of such an institution as an authoritative body on this essential industrial problem. For this reason the question of any merger must stand aside until you have finally decided upon your constitution. The Council hopes that on fuller consideration you may revise your present opinion on this essential point."

THE NEW SOUTH LONDON TUBE.—The extension of the South London Tube Railway from Clapham Common to Morden has now been completed, and the rolling stock delivered. Further work remains, however, to be done on the electrical equipment and the signal arrangements, but it is anticipated that the new section will be opened next month. Starting at 7 a.m., there is to be a service of thirteen trains per hour in each direction between Morden and Golders Green, *vid* the City, while twenty-six trains an hour in either direction will be run between Tooting-broadway and Euston, Highgate and Golders Green, also *vid* the City. There is also to be a connection for Charing Cross and the West End for each train to and from Morden. At the Morden end of the line some six motor omnibus services will connect the terminus with outlying places, and a new feature will be the provision of a modern garage for 200 private cars. It is believed that many motorists will be glad to leave their cars and to continue the journey to the City by train, thereby reducing to some small extent the street traffic in the City. When the new line opens, a considerable saving in time, as compared with the present joint omnibus and rail journey from Morden to the City stations will be effected. The total cost of the extension is stated to be round about £3,000,000.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	18/- to 21/-
(1) Spanish	18/- to 21/-
(1) N. African	18/- to 21/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 17 0	—
No. 1 Foundry	3 19 0 to 4 1 6	
No. 3 Foundry	3 16 6 to 3 19 0	
N.E. COAST—		
Hematite Mixed Nos.	3 18 0	3 18 0
No. 1	3 18 6	3 18 6
Cleveland—		
No. 1	3 18 0	3 18 6
Silicious Iron	3 18 0	3 18 6
No. 3 G.M.B.	3 15 0	3 15 6
No. 4 Foundry	3 14 0	3 14 6
No. 4 Forge	3 13 6	3 14 0
Mottled	3 13 0	3 13 6
White	3 13 0	3 13 6
MIDLANDS—		
(5) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 5 0 to 3 7 6	
,, Forge	2 16 0 to 2 17 0	
(3) Derbyshire—		
No. 3 Foundry	3 7 6 to 3 12 6	
Forge	3 2 0 to 3 3 0	
(3) Lincolnshire—		
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 7 6 (a); 4 10 0 (b); 4 15 0 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	11 5 0	11 0 0
Best	—	—
N.E. COAST—		
Common Bars	11 0 0	—
LANCS.—		
Crown Bars	11 0 0	—
Second Quality Bars	9 15 0	—
Hoops	14 0 0	—
S. YORKS.—		
Crown Bars	12 10 0	—
Best Bars	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	11 5 0 to 11 10 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 5 0 to 10 10 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	11 0 0	—
Ship Plates, ½in. and up	7 12 6	7 0 0
Sections	7 2 6	6 5 0
Steel Sheets, under 3/16in. to ¼in.	8 15 0 to 9 5 0	
Sheets (Gal. Cor. 24 B.G.)	—	£15 7 6 to £16 10s.

STEEL (*continued*).

	Home. £ s. d.	£ s. d.	Export. £ s. d.
N.E. COAST—			
Ship Plates	7 12 6		—
Angles	7 2 6		—
Boiler Plates	11 10 0		—
Joists	7 2 6		—
Heavy Rails	8 0 0		—
Fish-plates	12 0 0		—
Channels	10 5 0		£9 to £9 5
Hard Billets	8 2 6		—
Soft Billets	7 5 0		—
N.W. COAST—			
BARROW—			
Heavy Rails	8 0 0†		—
Light Rails	8 5 0	to 8 10 0	
Billets	8 0 0	to 10 10 0†	
MANCHESTER—			
Bars (Round)	8 0 0	to 8 5 0	
,, (others)	8 0 0	to 8 5 0	
Hoops (Best)	13 5 0		13 0 0
,, (Soft Steel)	10 0 0		9 15 0
Plates	7 17 6		—
,, (Lancs. Boiler)	11 10 0		—
SHEFFIELD—			
Siemens Acid Billets	10 10 0		—
Bessemer Billets	11 5 0		—
Hard Basic	8 12 6		—
Intermediate Basic	8 2 6		—
Soft Basic	6 15 0		—
Hoops	12 0 0		—
Soft Wire Rods	9 10 0		—
MIDLANDS—			
Small Rolled Bars	7 15 0	to 8 2 6	
Billets and Sheet Bars	6 2 6	to 6 5 0	
Sheets (20 W.G.)	11 10 0	to 12 0 0	
Galv. Sheets, f.o.b. L'pool	15 10 0	to 15 15 0	
Angles	7 2 6	to 7 7 6	
Joists	7 2 6	to 7 7 6	
Tees	8 2 6	to 8 7 6	
Bridge and Tank Plates	7 17 6	to 8 2 6	
Boiler Plates	11 0	to 11 15 0	

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	20/3 to 20/6
Block Tin (cash)	261 12 6
,, (three months)	260 10 0
Copper (cash)	56 5 0
,, (three months)	57 2 6
Spanish Lead (cash)	29 6 3
,, (three months)	29 11 3
Spelter (cash)	32 18 9
,, (three months)	33 6 3
MANCHESTER—	
Copper, Best Selected Ingots	62 0 0
,, Electrolytic	65 15 0
,, Strong Sheets	90 0 0
,, Tubes (Basis Price)	0 1 0½
Brass Tubes (Basis Price)	0 0 11½
,, Condenser	0 1 2
Lead, English	31 10 0
,, Foreign	30 12 6
Spelter	33 17 6

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/- per lb.	
Ferro Tungsten	1/9d. per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 10 0	7/6
,, 6 p.c. to 8 p.c. ,,	£22 0 0	7/3
,, 8 p.c. to 10 p.c. ,,	£20 15 0	6/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£38 10 0	12/6
,, ,, 1 p.c. ,,	£44 10 0	15/-
,, ,, 0·70 p.c. carbon	£54 10 0	17/6
,, ,, carbon free	1/5½d. per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 15 0 scale 5/- per unit	
,, ,, 75 p.c.	£20 10 0 scale 6/- per unit	
,, Vanadium	14/6 per lb.	
,, Molybdenum	6/- per lb.	
,, Titanium (carbon free)	0/11 per lb.	
Nickel (per ton)	£170	
Cobalt	10/- per lb.	
Aluminium (per ton)	£112	

FUELS.

SCOTLAND. (*Prices nominal.*)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	15/9
,, ,, Ell	16/6
,, ,, Splint	16/6 to 17/-
,, ,, Trebles	15/9
,, ,, Doubles	14/- to 14/6
,, ,, Singles	13/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/9
,, ,, Jewel	17/- to 17/6
,, ,, Trebles	17/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	12/6 to 14/9
Screened Navigation	21/-
Trebles	14/- to 15/-
Doubles	14/-
Singles	13/- to 13/6
LOTHIANS	
(f.o.b. Leith)—Best Steam	14/- to 14/3
Secondary Steam	13/6
Trebles	14/6 to 14/9
Doubles	13/6
Singles	13/6

ENGLAND.

	Inland.	Export.
(8) N.W. COAST—		
Steams		23/-
Household		40/- to 48/-
Coke		24/-
NORTHUMBERLAND—		
Best Steams		16/-
Second Steams		14/6 to 15/-
Steam Smalls		8/- to 8/6
Unscreened		13/- to 13/6
Household		20/- to 22/-
DURHAM—		
Best Gas		18/6 to 19/-
Second		15/- to 15/6
Household		20/- to 22/-
Foundry Coke		18/- to 20/-
SHEFFIELD		
Best Hand-picked Branch	31/- to 34/-	—
Barnsley Best Silkstone	28/- to 30/-	—
Derbyshire Best Brights	26/- to 28/-	—
,, ,, House	24/- to 25/-	—
,, ,, Large Nuts	17/- to 20/-	—
,, ,, Small	12/6 to 14/-	—
Yorkshire Hards	17/- to 19/6	—
Derbyshire Hards	16/- to 19/-	—
Rough Slacks	10/- to 12/6	—
Nutty Slacks	7/6 to 9/-	—
Smalls	3/6 to 6/-	—
Blast-furnace Coke (Inland)*	—	—
,, ,, (Export)	f.o.b.	16/- to 17/-

(9) SOUTH WALES. (*All prices nominal.*)

CARDIFF—	
Steam Coals:	
Best Smokeless Large	26/- to 27/-
Second ,, ,,	24/6 to 25/6
Best Dry Large	24/- to 25/-
Ordinary Dry Large	21/- to 22/-
Best Black Vein Large	25/6 to 26/-
Western Valley Large	24/6 to 25/-
Best Eastern Valley Large	24/- to 25/-
Ordinary ,, ,,	23/6 to 24/-
Best Steam Smalls	17/- to 18/-
Ordinary ,,	16/- to 17/-
Washed Nuts	19/- to 26/-
No. 3 Rhondda Large	26/6 to 27/-
,, ,, Smalls	18/- to 18/6
No. 2 ,, Large	24/- to 25/-
,, ,, Through	20/- to 21/-
,, ,, Smalls	15/- to 16/-
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	22/- to 24/-
Pitwood (ex ship)	19/- to 19/6
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	39/- to 40/-
Seconds	32/6 to 35/-
Red Vein	27/- to 29/-
Machine-made Cobbles	47/6 to 50/-
Nuts	47/6 to 50/-
Beans	42/6 to 44/-
Peas	23/- to 25/-
Breaker Duff	7/6 to 8/-
Rubbly Culm	12/6 to 13/6
Steam Coals:	
Large	22/6 to 24/6
Seconds	20/- to 22/-
Smalls	11/- to 15/-
Cargo Through	16/6 to 17/6

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayreshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market 17/6 to 19/- at ovens. † Latest quotations available. (a) Delivered Glasgow, (b) Delivered Sheffield. (c) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

International Steel Union.

In the present state of the iron and steel trades the only thing that interests manufacturers is the possibility of coming to some international arrangement for a distribution of foreign orders in proportion to each country's productive capacity. Otherwise, it is feared that the industry will fall into a state of hopeless depression arising out of the competition for a business which is necessarily declining during a period of monetary stringency. When European countries have to look to the ways and means of fulfilling financial obligations which will impose heavy burdens upon them, it necessarily follows that enterprise of all kinds is arrested and capital will not venture in industrial undertakings which are specially selected to bear the greater part of the fiscal load. The productive capacity of all countries has enormously increased, and makers have become more dependent on foreign business, with the result that competition is very keen and prices for export have fallen to an unprofitable level. Although French makers have been benefiting from a depreciated currency, they are perfectly aware of the precariousness of their situation, and they are as anxious as other continental producers to come to some international arrangement. At present the producing countries are divided into two groups which are carrying out negotiations independently, with the idea eventually of the two groups coming together for a final settlement. Germany, Belgium, Luxemburg, and France are still working hard to secure some tangible result, but they are encountering considerable difficulties, principally in fixing upon each country's quota of the foreign trade. In Belgium there are two firms which state that they intend to construct additional blast-furnaces and consequently claim a larger percentage, and in France a company declares that it is on the point of laying down a new steel works, so that it has become quite impossible, so far, to settle upon a participation acceptable to all. It is suggested that the only way out of the difficulty is to fix the proportion according to the production during the first quarter of the present year. In fact, it is only a belief in the absolute necessity of doing something to organise the continental trade that buoys up the hope of a successful issue to the negotiations. Meanwhile the steel makers in Czecho-Slovakia, Poland, Austria, and German Silesia are endeavouring to arrange with the Belgian and French producers for a meeting to be held in Switzerland during the present month, when the conditions under which an international steel union can be formed will be discussed. The final consitution of the Rail Union has also been held up on account of the somewhat exaggerated claims of continental makers, but another meeting is to be held in London on the 18th inst., when efforts will be made to fix upon the character of the British participation, which alone stands in the way of a final settlement.

The Rove Tunnel.

What is claimed to be the largest section tunnel in the world was inaugurated last week when water was admitted to the canal passing through the Rove Tunnel between Marseilles and Port de Bouc. A description of the tunnel was published in these columns four years ago. Having a length of 4½ miles, it has a width of 72ft. and a height from the bottom of the canal to the keystone of 50ft. 6in. The depth of water in the canal is 13ft. More than 2½ million c.m. of rock were removed from the tunnel. The canal itself has a length of 11 miles and puts the port of Marseilles into communication with the Rhone at Arles by way of the Caronte and the Etang de Berre. It will prove eventually of considerable commercial and economic value, and while permitting the navigation of large barges between Strasburg and Marseilles, when the canal between the Rhine and the Rhone is completed, it makes the Etang de Berre an extension of the port of Marseilles. Water was admitted to the canal by stopping the six large pumps which have been running continuously to drain the tunnel during excavation. The quantity of water filtering into the tunnel is about 1200 cubic metres an hour, and it will take about a month to fill the canal. The tunnel will be officially opened by the President of the Republic during the course of next year.

Aviation.

A long debate in the Chamber of Deputies upon the results obtained by military aviation compared with the money expended upon the purchase of aeroplanes showed how difficult it is to conciliate commercial interests with national requirements. The air service budget increased from 100 million francs in 1920 to 325 millions in 1925, and it was declared that 80 per cent. of the machines were of a type employed at the time of the Armistice, while those ordered since then have not given the best results. The threefold increase of the budget is not abnormal in view of the corresponding depreciation of money values, and the reproach that the air service has aimed more at keeping the aircraft industry alive than at securing the most suitable machines at fair prices is intended as a reflection upon the present system which places the air service under the immediate control of the War Department. Those who criticise existing methods are endeavouring to secure the appointment of an extra-Parliamentary Commission in the hope that it will recommend the creation of an independent Air Ministry. The Under-Secretary of State for Aeronautics urges in defence of the present condition of things that French aviation has made consistent progress and that the high position held by the French industry is shown by the fact that most of the world's records belong to French machines.

Paris Sewage.

Despite the efforts that have been made to prevent the pollution of the Seine and the Marne, it is reported that thirty-two communes are still discharging their sewage into those rivers above and below Paris. It is therefore proposed to construct large collectors outside the city for conveying the sewage to the farm at Acheres, which is already insufficient for present needs and will have to be considerably extended. The cost of the work is estimated at 800 million francs.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

250,877. January 14th, 1926.—SLEEVE VALVE ENGINES, J. S. Oliver, 30, Cadogan-place, London, S.W. 1.

In this engine the inventor aims at providing as large inlet and exhaust ports as possible, and also at opening and closing them very rapidly. In the drawings the sectional plan, Fig. 2, is

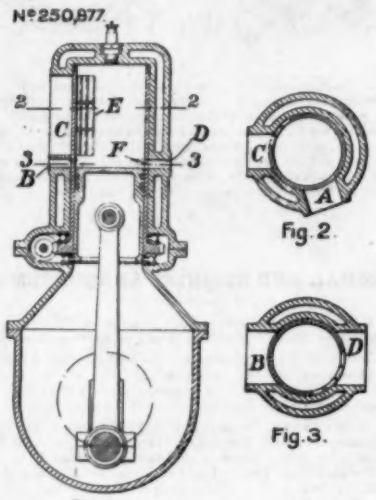
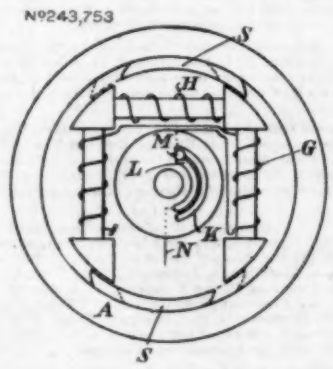


Fig. 1. Fig. 2. Fig. 3.

taken at the line 2-2, and Fig. 3 is a section at 3-3. There are two inlet ports A and B, and two exhaust ports C and D, while the valve sleeve has two openings E and F. By a combination of the rotary movement of the sleeve and the longitudinal movement of the piston inside the sleeve, the valves are very rapidly opened and closed, in spite of their large area.—*April 22nd*, 1926.

243,753. November 27th, 1925.—IMPROVEMENTS IN CURRENT-COLLECTING DEVICES FOR DYNAMOS, Ruthardt und Co., G.m.b.H., of 77, Hackstrasse, Stuttgart, Germany.

The dynamo described in this specification is suitable for providing lighting and ignition current on motor cars, the coils for generating the former being shown at G and those for the ignition current at H. The coils G are connected at one end to earth and at the other end to a slide bar. L is a similar bar connected by means of wires N through a centrifugal switch to the lamps. A sliding brush M is arranged adjacent to

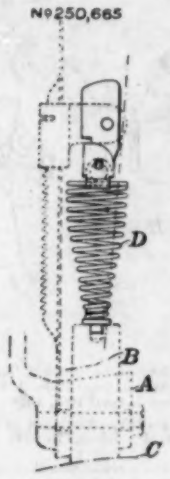


the two bars, so that it can make contact with both. This brush rotates with the fly-wheel A, which carries magnets S S; whilst the bars are stationary. The brush M only makes contact with both bars when the alternating current generated in the winding G passes either through the positive part of a cycle or through the negative part. Uni-directional current is therefore collected, so that a battery of accumulators may be charged. The bars may be arranged side by side, when the sliding brush M may be made to act as a centrifugal switch.—*April 22nd*, 1926.

DYNAMOS AND MOTORS.

250,665. January 15th, 1925.—BRUSH TENSIONING SPRING FOR DYNAMO-ELECTRIC MACHINERY, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2, and Alan Adair Pollock, of Croxton House, Sherbourne-place, Leamington Spa.

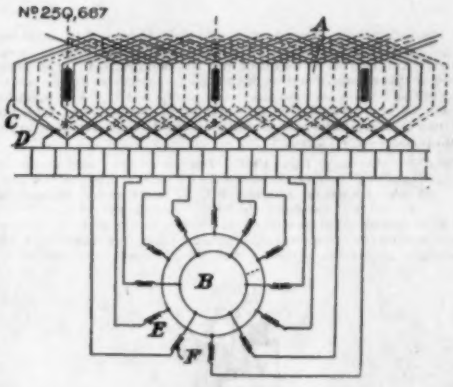
The inventors point out that a comparatively long helical brush spring which is in compression, and which is unsupported except at its ends, is very liable to buckle sideways, whilst if a spring of small enough diameter to enter the brush box as the brush wears down is made of stout wire with the object of avoiding buckling, it becomes too strong for the pressure it has to provide. Buckling has been avoided by making the springs barrel-shaped, but such springs are expensive to produce. A spring constructed in accordance with this invention is shown. The brush carrier is illustrated diagrammatically at A and the brush at B, whilst C is a portion of the commutator. The spring D is of conical form and the smallest end enters the brush box so that it maintains the pressure on the brush as the latter wears down. In order that the spring shall not be too stiff and in order to avoid buckling, the diameter of the large end of the spring is



made as great as possible. The preferred method of securing the brush carrier is described.—*April 15th*, 1926.

250,667. January 15th, 1925.—IMPROVEMENTS IN AND RELATING TO DYNAMO-ELECTRIC MACHINES, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2, and Frank Percy Whitaker, of 237, Clifton-road, Rugby.

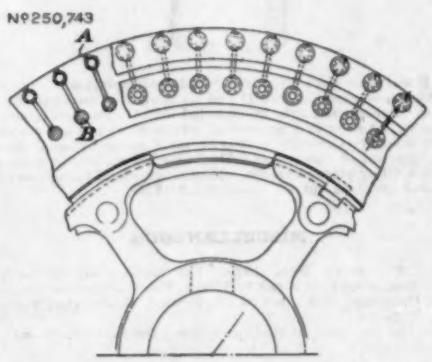
This invention relates to dynamo-electric machines, and more particularly to the type of machines known as motor converters. The object of the invention is to improve the commutation of machines of this type and it consists in providing the direct-current armature of the machine with a multiplex winding, each circuit of this winding being connected to a system of poly-



phase windings on the alternating-current rotor. A represents the direct-current rotor and B the alternating-current rotor. The direct-current rotor A is provided with a multiplex winding, consisting of two or more interleaved parallel circuits, such as C and D. The winding may preferably consist of a split turn multiplex winding. The separate windings C and D are respectively connected to sets of polyphase windings E and F of appropriate voltage and phase mounted on the alternating-current rotor B. The neutrals of the polyphase sets E and F may or may not be connected as desired, and the windings E and F may be connected to either the back or front end of the windings C and D.—*April 15th*, 1926.

250,743. March 30th, 1925.—IMPROVEMENTS RELATING TO INDUCTION ELECTRIC MOTORS, Donald Bright Hoseason, of "Grimsworth," Groby-road, Bowdon, Chester, and Metropolitan-Vickers Electrical Company, Ltd., of 4, Central-buildings, Westminster.

In the double winding squirrel cage rotor described in this



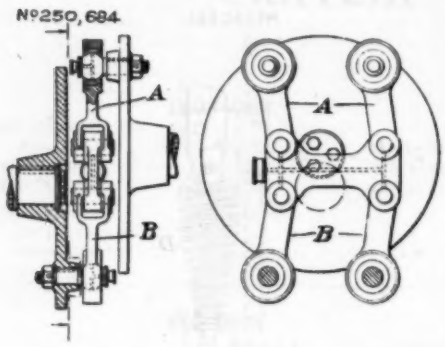
specification, tubular conductors A are employed for the high-resistance winding. These high-resistance conductors A are preferably situated at the periphery of the rotor core, so as to give maximum torque at starting, whilst the low-resistance conductors B, composed of copper rods, are situated within the core.—*April 22nd*, 1926.

TRANSMISSION OF POWER.

250,684. January 19th, 1925.—FLEXIBLE COUPLINGS, The English Electric Company, Ltd., 28, Kingsway, London, W.C. 2, and F. Morris, Sandholme, Broxbourne, Herts.

This coupling is specially put forward as being suitable for connecting the shaft of a spring-mounted electric motor, with

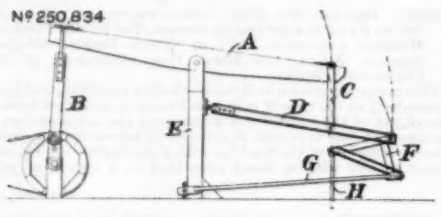
the unsprung axle of its vehicle, and is claimed to obviate any cyclical change of velocity in the driven part, regardless of the lack of concentricity of the two shafts. The construction of the



coupling is fairly obvious in the drawing, but it should be pointed out that each of the two pairs of links A A and B B must form sides of parallelograms.—*April* 19*th*, 1926.

250,834. October 7th, 1925.—A STROKE-MULTIPLYING PARALLEL MOTION DEVICE, P. Arbon, Box 111, Tulsa, Oklahoma, U.S.A.

It is suggested in this specification that the motion illustrated is specially suitable for the head gear of well pumping rigs. It comprises a normal walking beam A, driven by a crank and pitman B, from any convenient source of power. At the front end



of the beam there depends a pair of links C, which are attached to a secondary beam D. This beam is hinged to the sampson post E and carries at its outer end the bell crank F. The lower arm of this crank is tied back to the sampson post by the rod G, while the horizontal arm takes the pump rod H. The inventor does not give the relative proportions of the various parts, but claims that it gives a substantially straight-line movement to the pump rod.—*April* 22*nd*, 1926.

250,873. January 5th, 1926.—IMPROVEMENTS RELATING TO ELECTRIC CABLES, Johnson and Phillips, Ltd., of Victoria Works, Charlton, London, S.E. 7, and Charles Stewart, of "Blantyre," Beaconsfield-road, Blackheath, S.E. 3.

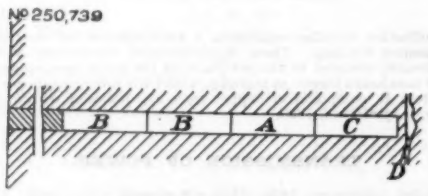
This specification describes an electric cable with an earthed bare conductor composed of stranded wires in contact with the metallic protecting screen which encloses all the conductors.

A, B and C are the leads of a three-phase supply, each lead comprising a conducting core D and an insulating envelope E. F is an earthed conductor of stranded metal wound on a core of jute G. An earthed protecting screen H of braded material surrounds the elements, and is enclosed in the external sheath J, composed of vulcanised rubber or other insulating material. K is a filling piece or cradle, whilst longitudinal filling pieces of rubber are shown at L.—*April* 22*nd*, 1926.

MISCELLANEOUS.

250,739. March 26th, 1925.—PREVENTING OR QUENCHING EXPLOSIONS OR FIRES IN MINES, The Washington Chemical Company, Ltd., and G. S. Newall, Washington Station, Durham.

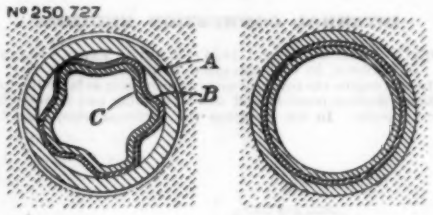
In the preamble of this specfication the inventors point out



that when a number of shots are fired successively at a coal face there is a corresponding accumulation of coal dust, and consequent increased liability for an explosion. For this reason they sandwich the explosive charge A in the shot hole between packages B B and C of basic carbonate of magnesia, which, they say, will be dissociated into carbonic acid gas, water vapour and oxide of magnesia, all of which will tend to quench any flame. The package C of magnesia is intended to guard against any "blow through" into a fissure or old working D.—*April* 22*nd*, 1926.

250,727. March 9th, 1925.—CASTING CONCRETE CULVERTS IN SITU, Toichi Nose, No. 86, Nikaido, Kamakuri Machi, Kamakura Gun, Kanagawa Ken, Japan.

The inventor explains that while inflatable cores for moulding the interior of culverts have been used heretofore, some difficulty has been experienced in removing the bag-like cores after they were deflated. He therefore makes the core of two distinct



parts, or thicknesses. The outer part A is of india-rubber and is slightly smaller than the desired size of culvert. The inside part is made of an inextendable fabric tube B, lined with rubber C to make it air-tight. When in use, as shown on the right in the drawing, the composite tube is stretched to the required diameter by the internal air pressure; but when the pressure is released the outer part A contracts, crumpling up the inner tube, and the core can be readily withdrawn.—*April* 22*nd*, 1926.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

SIR DOUGLAS BROWNRIGG, Bart., has been elected chairman of directors of Michell Bearings, Ltd., of Newcastle-on-Tyne.

Iron and Coal Trades Review asks us to state that it has moved from Bessemer House, Adelphi, to 49, Wellington-street, Strand, W.C. New telephone number, Gerrard 3951 (four lines); telegraphic address, "Zacatecas, Rand, London."

MR. ALEXANDER C. CRAMB, M.I.E.E., M.I. Mech. E., Engineer and Manager of the Electricity Department of the County Borough of Croydon, has accepted the invitation of the Council of the Institution of Public Lighting Engineers to take the office of vice-president so as to become president of the Institution in 1927, when the annual meeting and conference will take place at Brighton.

THE Council of the Institution of Structural Engineers announces that it has purchased the house known as 10, Upper Belgrave-street, London, S.W. 1, as headquarters for the Institution, and that the offices of the Institution will be removed to that address as and from June 24th next, after which date all communications should be so addressed. It is hoped that the telephone numbers will remain as before, Victoria 3131 and 3132, and the telegraphic address will be "Coninst, Sloane, London."

CONTRACTS.

CLAYTON WAGONS, Ltd., of Abbey Works, Lincoln, has received from the India Office an order for one of its latest type tandem steam road rollers.

THE WELLMAN SEAVER ROLLING MILL COMPANY, Ltd., of 36–38, Kingsway, London, W.C. 2, has received an order for a complete new plant for the manufacture of weldless steel tubes. The value of this order approaches £100,000.

ALLOYS WELDING PROCESSES, Ltd., of 14–16, Church-street, Islington, London, N. 1, has received from one of the Indian State Railways an order to supply three electric arc welding machines, each of which is to be able to supply current to two operators.

ED. BENNIS AND CO., Ltd., of 28, Victoria-street, Westminster, S.W., have received from Charles Mackintosh and Co., Ltd., Cambridge-street, Manchester, who were recently taken over by Messrs. Dunlop, an order for five sprinkler stokers and five independent bucket elevators for their set of five Lancashire boilers.

INTERNATIONAL COMBUSTION, Ltd., of Africa House, Kingsway, W.C. 2, informs us that its associated company in America has recently received orders for Lopulco pulverised fuel equipment from (*a*) the Boston Elevated Railway, Boston, Mass.; (*b*) the New York Steam Company, New York City, N.Y.; (*c*) the Metropolitan Power Company, Reading, Pa.; (*d*) the Detroit Edison Company, Trenton Channel Plant; and (*e*) the Fisher Body Corporation, For, Memphis, Tenn. The same firm has also received orders for forty-three stoker-fired boilers and for two patented combustion steam generators.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., of Trafford Park, Manchester, has received from the Great Indian Peninsula Railway an order for forty-one electric goods locomotives for the main line electrification from Bombay to Igatpuri and Poona. The locomotives will be of the side rod type with motors mounted above the deck. They will have two trucks, each with three axles, the trucks being coupled together with an articulating joint, a single body being mounted on a pair of trucks. Each truck will have a twin motor of 1300 horse-power rigidly mounted on it and driving a jack shaft through single reduction gearing, with gears on each side of the motor. The horse-power of each locomotive will therefore be 2600 horse-power on the one-hour rating.

PORTLAND HOUSE SCHOLARSHIP.—The Institution of Structural Engineers announces that the date of the preliminary examination for the Portland House Travelling Scholarship (£300) has been postponed to June 19th. The final competition—Designing a Reinforced Concrete Structure—will now take place on July 3rd.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday afternoon, June 7th, Sir Arthur Keith, treasurer and vice-president, in the chair. The chairman announced that the president had nominated Sir James Crichton Browne, Dr. J. Mitchell Bruce, Sir Ernest Moon, Sir Edward Pollock, Sir Almroth Wright, Sir Alfred Yarrow, and Sir Arthur Keith, treasurer, and Sir Robert Robertson, secretary, as vice-presidents for the ensuing year. Mr. W. H. Inskip, Mrs. James Mitchell, Dr. Boris Orelkin, Dr. H. R. Rice, and Dr. J. F. Tocher were elected members.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY AND SATURDAY, JUNE 12TH.

INSTITUTION OF WATER ENGINEERS.—Summer meeting in Manchester. For programme see page 460.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Meeting in the Scottish District at Kilmarnock. For programme, see page 561.

TO-DAY TO SATURDAY, JUNE 19TH.

FOUNDRY TRADES' EXHIBITION at the Royal Agricultural Hall, Islington, London, N. 1. 11 a.m. each day.

TO-DAY.

PHYSICAL SOCIETY OF LONDON.—Imperial College of Science, South Kensington, London, S.W. 7. Papers: "The Latent Heat of Fusion of Some Metals," by Mr. J. H. Awbery and Dr. Ezer Griffiths; "The Piezo-electric Quartz Resonator and its Equivalent Electric Circuit," by Mr. D. W. Dye; "The Characteristics of Electrostatic Machines on Non-inductive Loads and on the Coolidge Tube," by Mr. E. J. Evans. 5 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "The Spectrum of the Aurora," by Professor J. C. McLennan. 9 p.m.

SATURDAY, JUNE 12TH.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Visit to Nottingham and works on the river Trent. 1 p.m.

MONDAY, JUNE 14TH.

FARADAY SOCIETY.—Institution of Mechanical Engineers, Storey's Gate, London, S.W. 1. Discussion on "Explosive Reactions in Gaseous Media" (Postponed from May 13th). 2.30 p.m.

MONDAY TO FRIDAY, JUNE 14TH TO 18TH.

INSTITUTION OF MECHANICAL ENGINEERS.—Summer meeting at Ipswich

WEDNESDAY, JUNE 16TH.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, London, S.W. 1. Conversazione. 8–11.30 p.m.

FRIDAY, JUNE 18TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Council's Garage, Millfields-road, Lower Clapton, N.E. Metropolitan District meeting. 4.30 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Yorkshire District meeting at Spenborough. 10.30 a.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "The Golden Eagle and its Neighbours," by Mr. Seton Gordon. 9 p.m.

SATURDAY, JUNE 19TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—South Midland District meeting at Kettering. 11 a.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—North-Eastern District meeting at Stockton-on-Tees. 10.45 a.m.

MONDAY TO WEDNESDAY, JUNE 21ST TO 23RD.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Summer Meeting at Scarborough.

MONDAY TO SUNDAY, JUNE 21ST TO 27TH.

INSTITUTION OF NAVAL ARCHITECTS.—Summer meeting in Belgium. For programme, see page 588.

WEDNESDAY TO FRIDAY, JUNE 23RD TO 25TH.

NEWCOMEN SOCIETY.—Summer meeting at Norwich. For programme, see page 565.

WEDNESDAY TO SATURDAY, JUNE 23RD TO 26TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Annual general meeting and Conference at Bristol. For programme, see page 506.

FRIDAY, JUNE 25TH.

DIESEL ENGINE USERS' ASSOCIATION.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Some Deleterious Properties of Lubricating Oils," by Mr. J. E. Hackford.

MONDAY, JUNE 28TH.

FINSBURY TECHNICAL COLLEGE OLD STUDENTS' ASSOCIATION.—Finsbury Technical College, Leonard-street, London, E.C. 2. Silvanus Thompson Memorial Lecture, "The Rise of Atomic Physics," by Mr. C. A. Darling. 8 p.m.

THE INSTITUTION OF CIVIL ENGINEERS.—The Council of the Institution of Civil Engineers has recently made the following awards in respect of papers read and discussed at the ordinary meetings during the session 1925–1926:—A Telford Gold medal to Mr. O. L. Prowde, B.A., M. Inst. C.E. (Makwar, Sudan); a Watt Gold Medal to Mr. H. R. Lupton, M.A., Assoc. M. Inst. C.E. (Leeds); Telford Premiums to Messrs. A. S. Angwin, D.S.O., M.C., B.Sc. (Eng.), Assoc. M. Inst. C.E., and T. Walmsley B.Sc. (Eng.), Assoc. M. Inst. C.E. (London); V. Bayley, C.I.E., M. Inst. C.E. (London); C. F. Bengough, M. Inst. C.E (Tewkesbury); A. Honeysett, Assoc. M. Inst. C.E. (London); J. N. Reeson, M. Inst. C.E. (Melbourne, Victoria); and H. A. Reed, M. Inst. C.E. (Manchester); and a Crampton Prize to Colonel G. R. Hearn, C.I.E., D.S.O., R.E., Assoc. Inst. C.E. (Calcutta). The Council has also awarded the Coopers Hill War Memorial Prize for 1925, consisting of a bronze medal, parchment certificate and a sum of money, to Mr. E. L. Everatt, Assoc. M. Inst. C.E. (Bombay). This prize was founded by the Coopers Hill Society in memory of Coopers Hill men who lost their lives in the war.